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Flanged Motor Mountings
on Foreign Machine Tools

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NUMEROUS factors indicate that flange-type motor mountings and other types of mountings in which the motor is "designed into the machine," so to say, usually with direct connection to the work spindles or to other parts, are increasing in popularity. Abroad, particularly in Germany, and to a less extent in England, a large variety of machine tools already are offered with these types of mounting, while a number of American manufacturers, especially of drill presses, grinders and lathes have adopted similar mountings on some models.

It is not to be expected that the conventional motor with base mounting and belt or chain drive will be abandoned, either for machine tools or for other types of machines, where such an arrangement has definite advantages over other forms of mounting and drive, but where compact arrangement and direct drive offer material improvements, either in convenience, better appearance or on other scores, this type is more than likely to be adopted. This fact is recognized by motor manufacturers as well as by machine builders, and some of the former already are offering motors for flange mounting. One reason for this is that various types of motors of given rating for foot or pedestal mounting in general are not interchangeable mechanically, except in fractional horsepower sizes. Such interchangeability as between a.c. and d.c. motors readily is accomplished, however, if flange mounting is adopted, and for this reason much money frequently can be saved by employing flange mountings for machines which may go into plants where either a.c. or d.c. power is available, but not both kinds.

Moreover, flanged motors often can be mounted to advantage partly or wholly within the machine to be driven, thus often saving in floor space and obviating the extra cost of special brackets or platforms. By the use of a square flange or one cut off flush with the motor frame at top, bottom and sides, motors can be mounted side by side on closer centers than if full circular flanges are employed, and this is an advantage of importance in certain cases.

Frequently the use of a flanged motor results in locating this important unit in a position where the chances of chips, coolant or other foreign matter causing shorts or other injury is reduced materially. This is true, in particular, with vertically mounted motors placed well above the work-table, or, as in many drill presses, at the extreme top of the machine. In such cases, of course, proper protection against dust and provision of adequate lubricating facilities must not be neglected.

While it is true that a flange is one of the most convenient means of mounting an "integral" or direct-drive motor, it is true also that other forms of mounting, especially the sleeve or barrel type, gives many of the same advantages. Both flange and barrel mountings are used extensively and, in fact, have been standardized, in the case of automobile starting motors and lighting generators. Although these are fractional horsepower machines, the advantages of these types of mounting are similar to those obtained with larger motors on other classes of machines.

This article deals largely with foreign design in flanged motor mounting on machine tools. American practice in respect to this type of mountings on several classes of machines will be covered in another article in an early Product Engineering number. Additional information and drawings, which may be submitted by readers as a result of their experience in the design or redesign of any type of machine tool or production machinery to incorporate flanged motors, will be given due consideration.

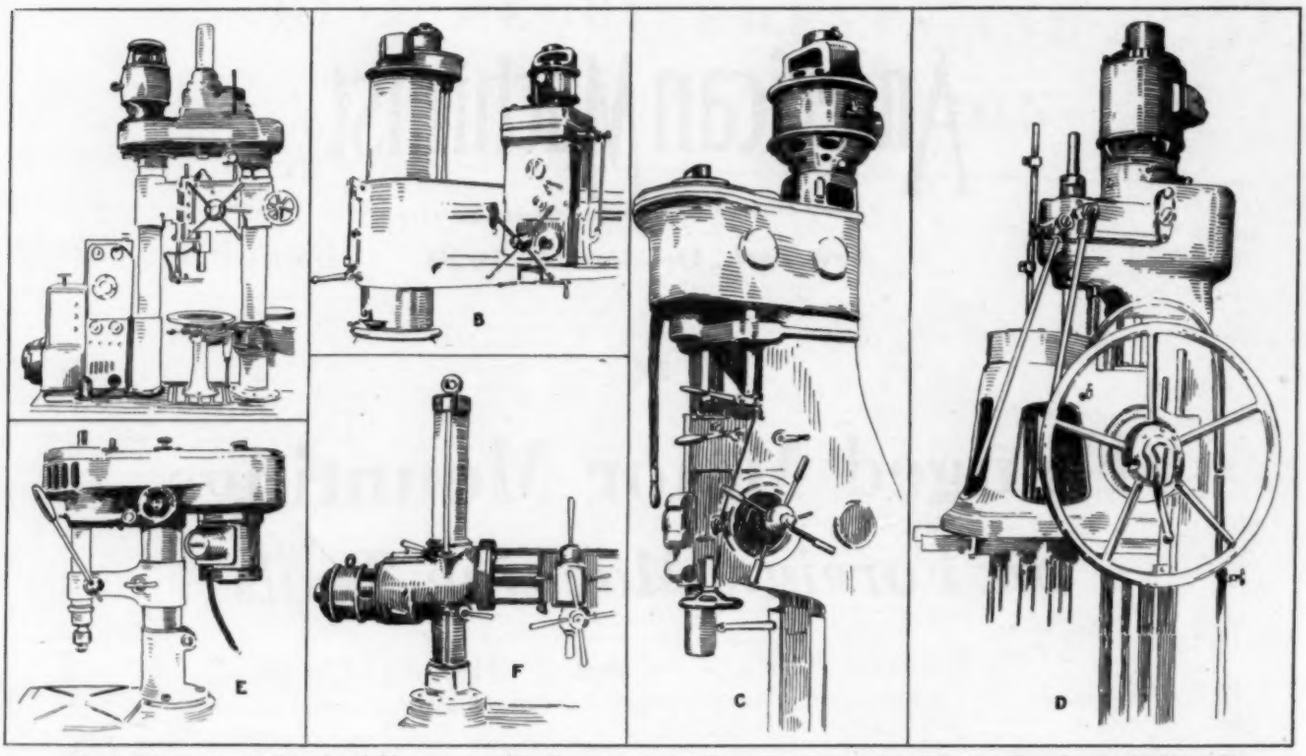


Fig. 1—A group of German drill presses with direct-connected flanged motors: *A* and *E*, two Wesselmann designs; *B*, Kolb radial; *C*, Schütte; *D*, Habersang & Zinzen multiple-spindle; *F*, Loewe radial

Incidentally the flange-type automobile generator usually is driven either by belt or chain, the mounting being of such a nature that slack can be taken up by turning the generator about one flange bolt, or by shifting it bodily after loosening bolts which pass through slots in the flange.

Flange-type motor mountings are far from being a new development. Their use on machine tools, however, has progressed further abroad than in this country. The European edition of *American Machinist* published the following comment after the Leipzig Machine Tool exhibition of March, 1928. "Flanged motors, which English firms have been somewhat slow to adopt, were everywhere in evidence. Many applications showed how readily they adapt themselves to the general design of the machine, which consequently appears to have been thought of as a whole."

On the other hand, in a paper by E. W. Tipple, M.I.M.E., delivered during the machine tool and engineering exhibition at Olympia, London, in 1928, the following statement was made with regard to flanged motors: "While the writer agrees that the appearance is generally improved thereby, he sincerely questions the desirability of following this practice for the following reasons."

1. It has the effect of placing the machine tool builder in the hands of one or two electrical concerns.

2. The export market has too wide variation of voltage and frequency.

3. The speed of a direct-coupled motor is too high to be interchangeable with pulleys.

4. If the drill spindle passes through the motor, the design is not to be questioned, if gearing is introduced, it has to be of large dimensions in order to have the spindle clear the motor casing, with the result that tooth velocities are unnecessarily high and oil is thrown off the gears. In such cases the writer questions whether the design is preferable to mounting the motor at the end of the arm, and mounting the transmission shaft on anti-friction bearings."

That objections with regard to high tooth velocity, and interference of the motor casing can be met is evident from the accompanying illustrations.

German manufacturers of machine tools have some unusual methods of mounting motors of this type. Drilling machines, both radial and upright, furnish most of the examples along this line. Practically all of the principal German radial drill manufacturers use two vertically mounted motors, one for elevating and lowering the arm and the other, mounted on the saddle, for driving the spindle, as will be seen from the sketches in Fig. 1. Twelve German and five English firms advertise drills driven in this manner. Several examples of British practice are given in Fig. 3. The use of individual motors, bringing the source of power as close as possible to the point of application, is becoming more and

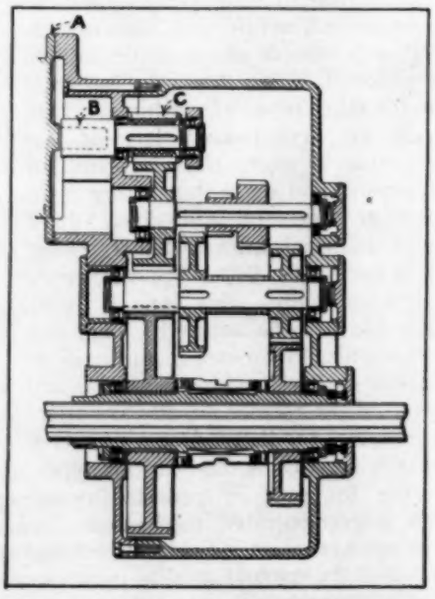


Fig. 2—Gear box designed for use with flanged motor mounted at *A*. The shaft extension *B* carries the driving pinion *C*

more common. This arrangement tends to eliminate one fundamentally incorrect feature in design, that of speeding up and then down again in order to obtain a satisfactory range of speeds.

In Fig. 2 is shown diagrammatically a gearbox design which meets the objection regarding high tooth velocities and also avoids interference between motor casing and gears. The motor is mounted by the flange *A* to the gearbox housing, and its shaft is provided with an extension *B*, supported in two ball bearings. On this extetnsion is pressed a pinion *C*, which might have been made even smaller in diameter by forming it as an integral part of the extension shaft. In other cases the extension shaft is splined to accommodate sliding gears.

Ordinarily it is a simple matter to adapt a motor for flange mounting. In some cases one end-housing is merely fitted with a flange which provides a rigid support. Vertical motors sometimes have a separate mounting ring and others employ an integral flange. Two German d.c. motors arranged for flange mounting are illustrated in Fig. 4.

Several examples of foreign designs of lathes, some of them with automatic features and all fitted with flange-mounted or similar forms of motors, are shown in Fig. 5. Some American lathes use similar mountings.

At least four European makers of milling machines employ flanged or other integral types of motor mountings and some American machines of this class are beginning to employ a similar construction. Examples of foreign practice are shown in Fig. 6. At least one German maker, Loewe, applies integral motors to a planer-type milling machine.

Two German makes of horizontal boring machines,

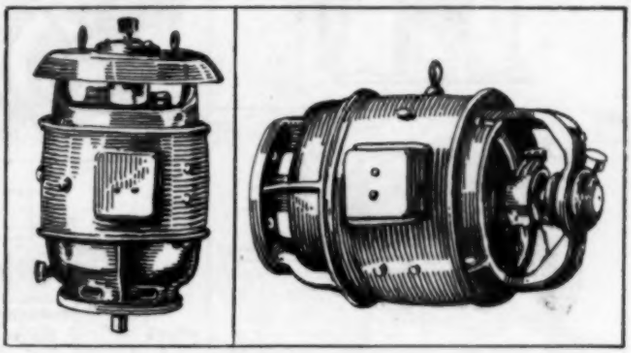


Fig. 4—Two flange-type direct-current motors made in Germany

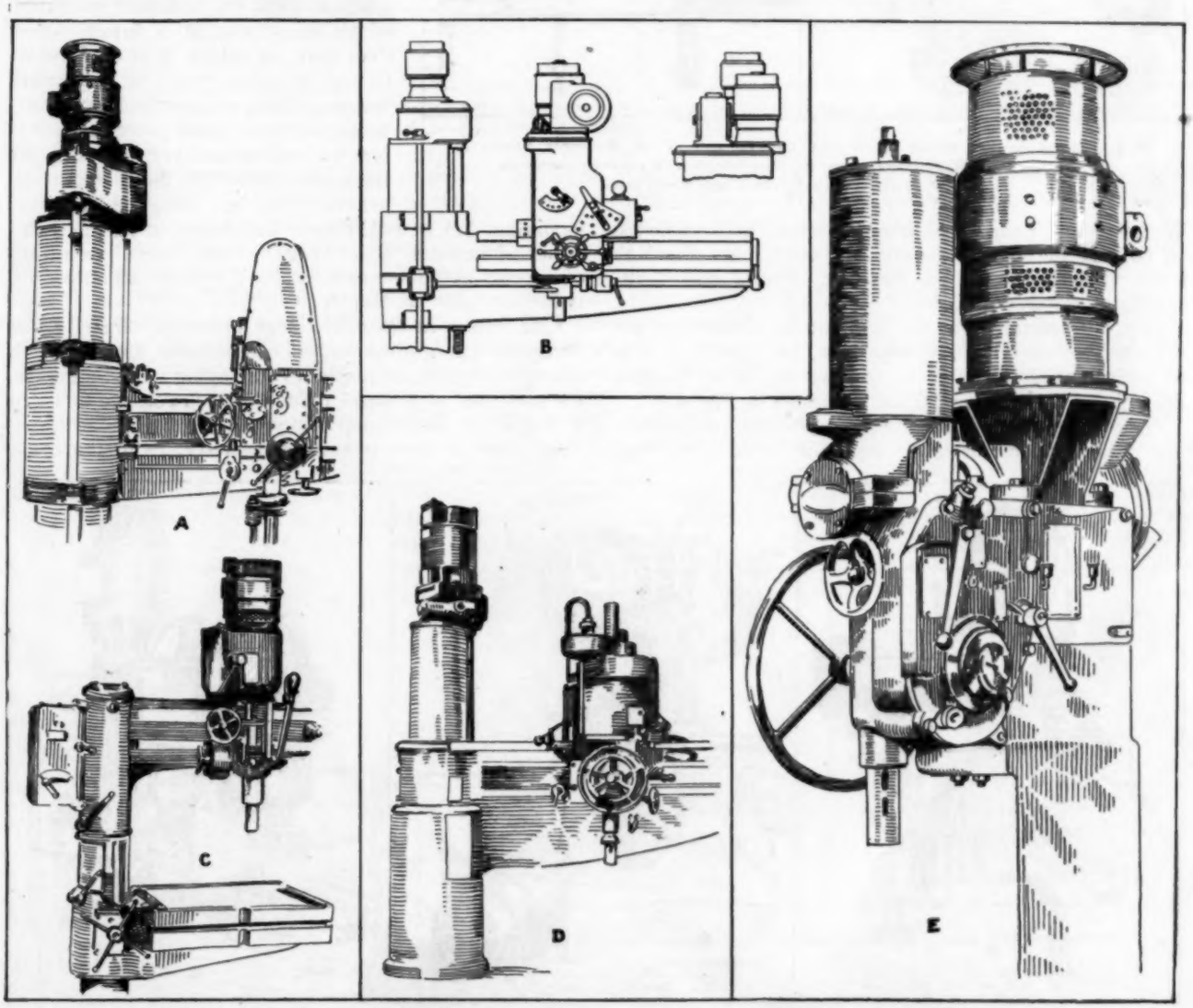


Fig. 3—Drill presses of British design employing flanged motor mountings; *A*, Archdale radial, with B.T.H. motor; *B*, Swift "Superadial," with two motors; *C*, Kitchen & Wade sensitive radial; *D*, Asquith radial; *E*, Archdale vertical

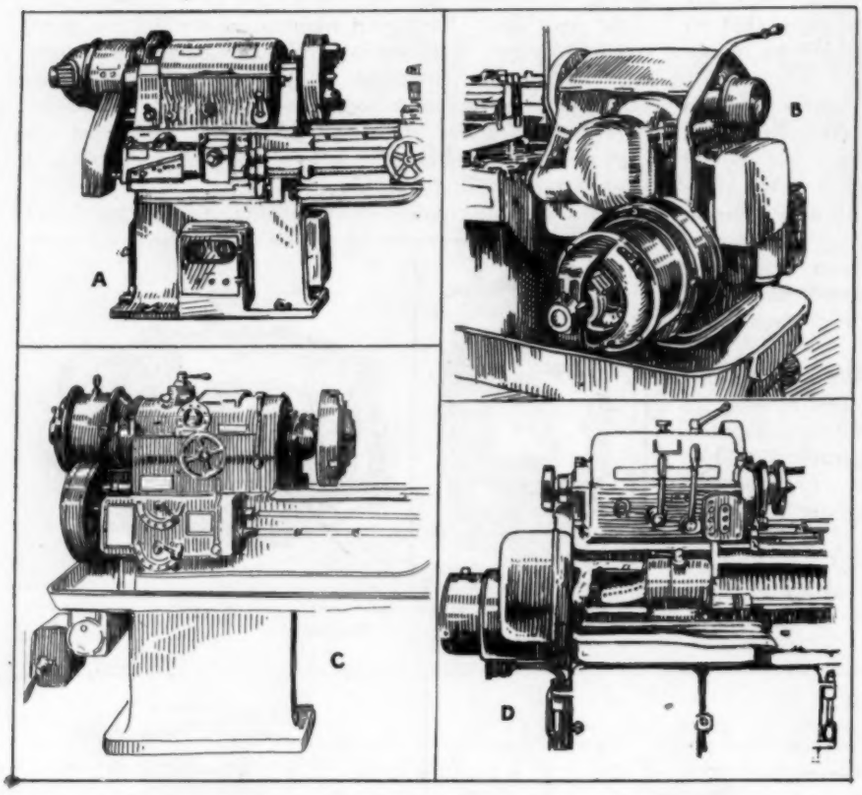


Fig. 5—Four foreign lathes fitted with flanged motors: *A*, Boringer Bros.; *B*, Loewe; *C*, M.W.F. lathe made by Magdeburger Werkzeugmachinen Fabric; *D*, Dean, Smith & Grace tool room lathe

Wetzel and Union, have integral motor arrangements. In two of the Union designs the motors are fitted to heads at each end of the machine. Fig. 7 shows examples of these applications.

Motor mountings of the type under discussion are not confined merely to rotary tools, but are fitted also to reciprocating tools such as shapers. One German example of such an application are given in Fig. 8.

Grinding machines of numerous different forms make use of integral motor mountings, for in this case high speeds are the rule and problems of gearing are either less difficult or non-existent. In the simplest form, the motor shaft serves as the spindle carrying the grinder wheel or wheels, but there are, of course, alternative arrangements as will be seen by reference to Fig. 9. In many cases more than one motor is employed. Examples of two German applications are given in Fig. 9, the Werner machine, at the left being for grinding splined shafts, and the other Wotan machine, for internal grinding. At least three British manufacturers make vertical-spindle surface grinders with integral motors.

In Germany the desirability of direct drive is considered so important that more or less "standard" reduction gears fitted with flange-type motors are offered by the Saxonia Works and A.E.G. These gearsets are designed not alone for driving machine tools, but for other machines which must run at a lower speed than that for which it is economical to use a direct-connected ungeared motor. They are available in practically any low speed, power capacity, type of current and voltage. Fig. 10 illustrates three of these reduction gears. They are designed for base mounting, but it would seem that some, at least, of the same advantages which result from flange mounting of motors could be realized by a similar mounting of reduction gear units.

One reason in favor of flange mounting alluded to in foregoing paragraphs, and of considerable importance to nearly all makers of machines employing motor drives, is the fact that, with flange mounting, it is possible to attain a degree of interchangeability not heretofore achieved. With foot or base mounting most d.c. motors are not

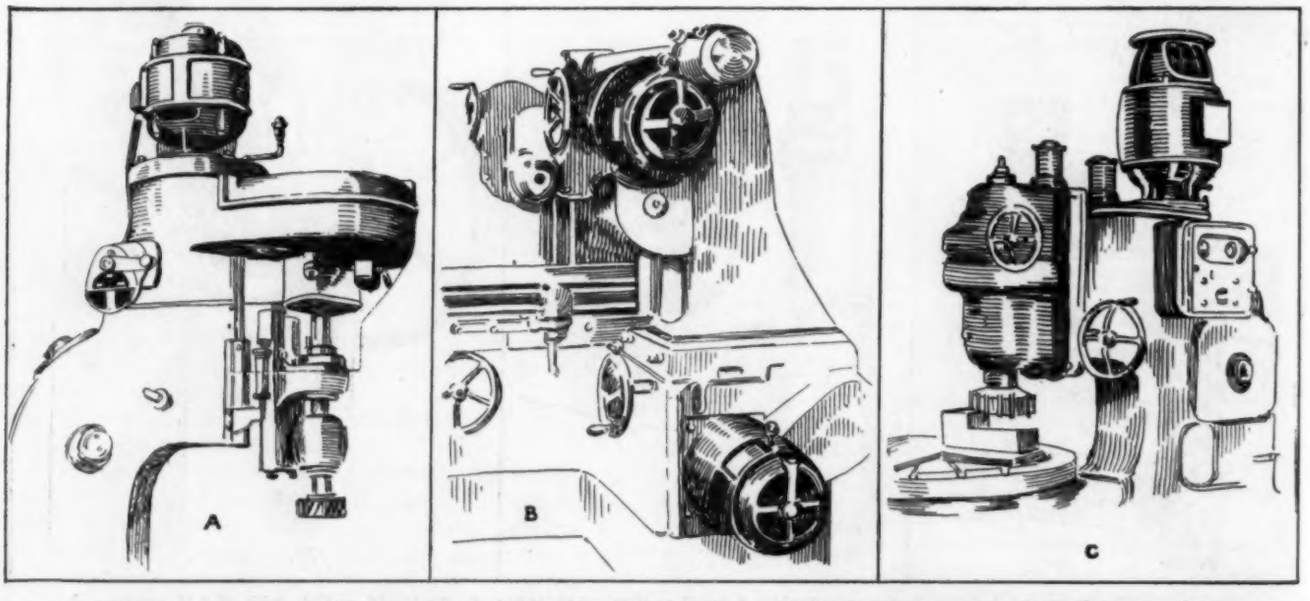


Fig. 6—Three German milling machines driven by flanged motors: *A*, Mueller & Montag vertical; *B*, Loewe planer-type miller; *C*, Loewe vertical miller with DIN motor

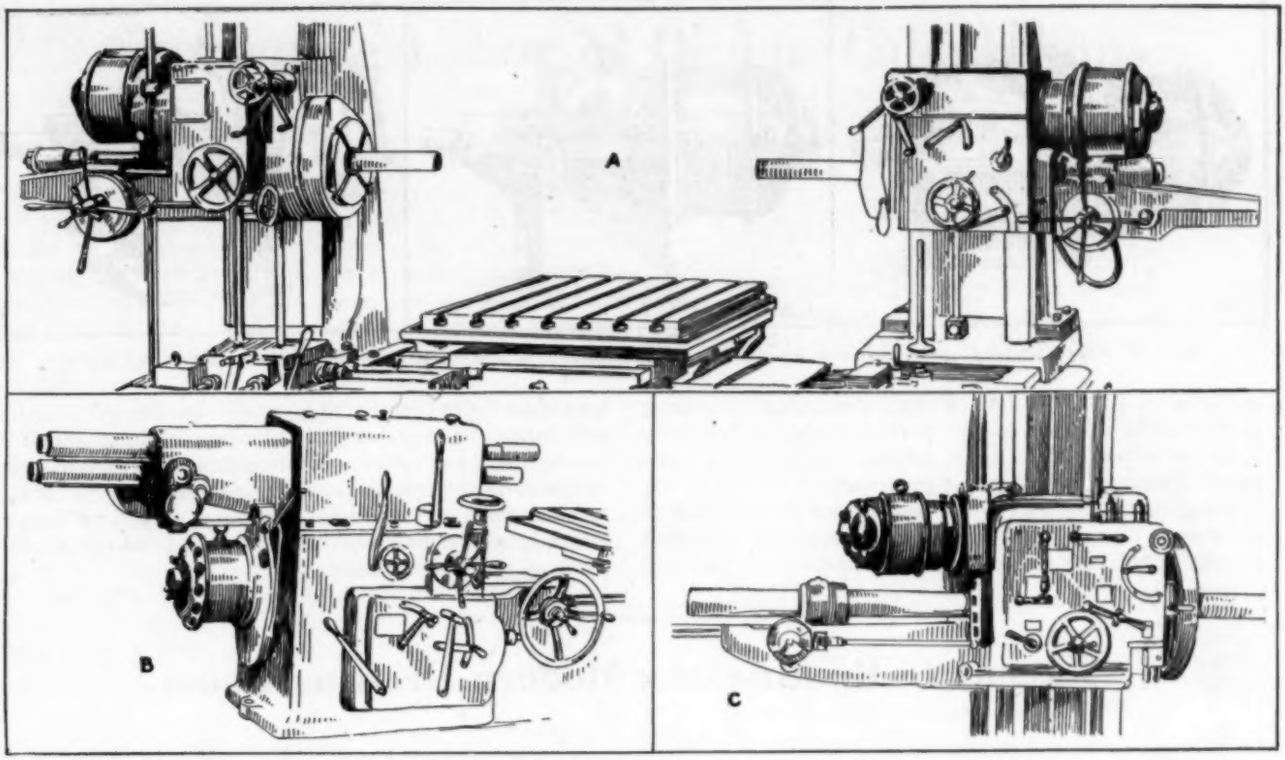


Fig. 7—Three German horizontal boring mills with flanged motors: *A* and *B* Union double- and single-head designs; *C*, work-head of Wetzel fitted with either d.c. or a.c. motor

mechanically interchangeable with equivalent a.c. types. In consequence, if the machine manufacturer's product is likely to be used in installations where either a.c. or d.c. power is available, but not both, provision for mounting an a.c. motor in one case and a d.c. motor in the other must be made. Often this means a change in the base to which the motor is attached, or, if a bracket is employed, an entirely different casting may be required. Provision for such mountings frequently involve delays and extra expense both of which could be avoided if an interchangeable mounting flange, which is entirely feasible, were employed.

At least one prominent motor manufacturer has recognized this advantage and is offering not alone motors which are mechanically interchangeable as between a.c. and d.c. types of the same power rating, but groups comprising several motors, all interchangeable on the same flange. Thus it appears that the long-desired interchangeability can be realized where flange mounting is adopted. Whether this will apply as between motors of different makes will depend upon whether the various interests involved can agree upon a set of standard dimensions.

A glance at the accompanying cuts indicates that a considerable proportion of the flange-mounted motors used abroad for machine tool drives are vertical types, in which a flange appears to be the most "natural" type of mounting, whereas in horizontal motors perhaps the most obvious arrangement is to allow the motor to stand on a pedestal. This may be due to the fact that designers are accustomed to consider the motor as a thing apart from the machine it drives. If, however, it be considered as

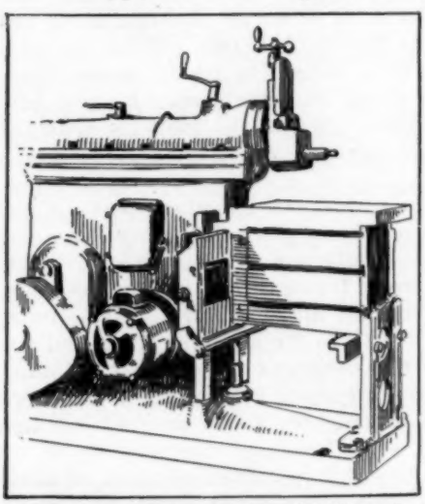


Fig. 8—A German shaper with flanged motor, produced by the Samson Works

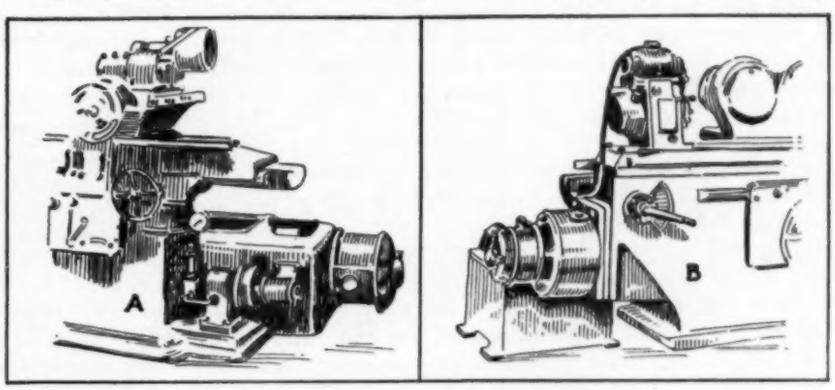


Fig. 9—Two examples of foreign grinders having flanged motors

Problems of gearing are generally less difficult on grinding machines for the reason that high speeds are the rule. The motor shaft serves as the spindle in the simplest form, but in some cases, as here illustrated, the motor is apart from the spindle and is flange mounted.

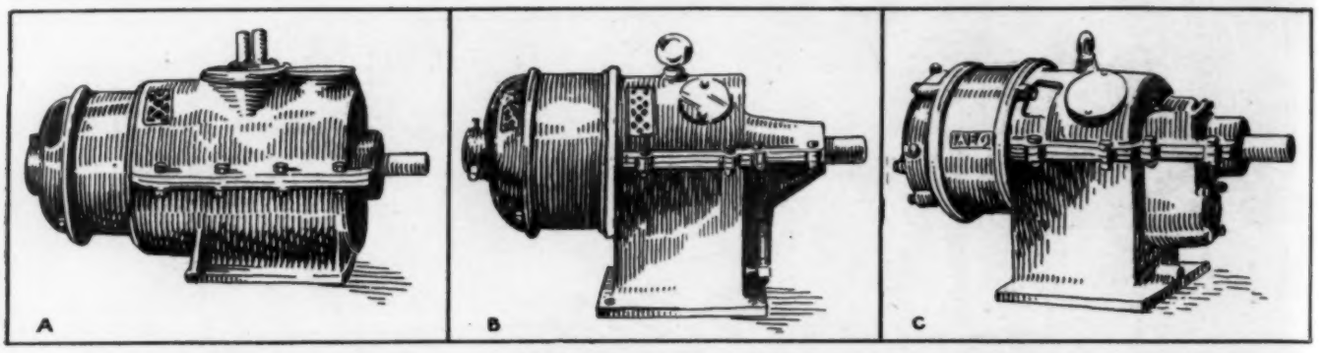


Fig. 16—Three German speed reducers fitted with flanged motors: *A* and *B*, by Saxonia Works; and *C*, by A.E.G.

an integral part of the machine, the logical mounting appears to be a flange, except, perhaps, where a belt drive is to be employed for some special reason or, in some cases, where a chain drive is preferred.

The general problem is not unlike that encountered in automobile design. Advocates of the separately mounted gearset could cite certain apparent advantages for that type, but today nearly all gearsets are flange mounted, and form an integral part of the power plant. Such an arrangement has certain disadvantages but they are outweighed, in the opinion of most engineers, by the advantage of positive, fixed alignment, and a type of support which is secure and requires no special brackets or other external supporting means.

Executive Routine of a Modern Drafting Room

By Lloyd Y. Squibb

CHIEF draftsmen in a modern drafting room must be more business managers than designers. They have entire charge of personnel after they are sent to them by the employment department, and full authority over anyone in the department without question or discussion. All men entering the chief draftsman's employ should be required to declare their ability on an application card for his reference, so that if a man misrepresents his ability he has only himself to blame for consequent reduction or discharge.

The assistant chief should handle the administrative details of the drafting room. He should assign all work to the men, and supervise it throughout its passage through the drafting room. The chief draftsman remains in the background as much as possible. This will place him in a position to judge and decide questions in an impartial, clear cut way that will be satisfactory to all persons concerned.

An assistant chief draftsman should assign all work. With the proper personnel, there is very little supervision required, and he will have sufficient time to handle all details of the work. Suppose for example, a tool is to be designed. The assistant chief receives the blueprint and the sequence of operations and tools from the shop executives. After a conference with them, he decides upon tolerances, clearances, locating points, methods of handling, and assignment and routing through the drafting room, as well as what jigs, fixtures, and similar equipment are to be used. The job is then given to the tool designer. After his work is completed, the parts are given to the designers, the more important ones to leading designers, and less important ones to subordinates. Each designer does the work assigned to him, and decides the number of drawings necessary. The work is then returned to the assistant chief, who assigns it to a checker—who is a designer part of the time and a checker the remainder. Checkers corrections are made, the job is submitted to the shop executives, and the accepted drawings are assigned to detailers. The assistant chief answers any questions that arise in detailing. Details are checked as before, and the job is ready for the shop.

The assistant chief has a more simple job than this discussion would indicate. There are several reasons for this condition, but principally it is because unnecessary discussion has been eliminated. First, the blueprint of the part to be machined is correct, and is not subject to discussion. Second, the tentative sequence of operations is usually correct. Third, the method of manufacture is decided upon in actual consultation by shop executives and the assistant chief. Fourth, the designer knows exactly what is expected of him without question or discussion. In fact, designers can be started on all operations at once. One is not dependent on the other. The designer does not follow up his work, so the design must be complete and clear. Fifth, the detailer receives his work from the assistant chief and goes along with his part of the work without question or discussion. If he is obliged to ask for information, the question is taken up with the assistant chief, who can decide immediately whether the fault lay with the designer or the detailer and can then decide upon a course of action.

Lastly, the checkers play an important part. Their rôle is a double one. To begin with, they are the best designers available, capable of designing tools or machinery. They alternate between checking and designing the more important tools and machines. The checker refers the checked work to the assistant chief, and has no contacts with the designers or detailers. Consequently, unnecessary argument is eliminated and work proceeds much more smoothly in its progress through the drafting room.

This system worked well in a drafting room of about 25 men in the designing of tools and special machinery, as well as parts, for an internationally known machine.

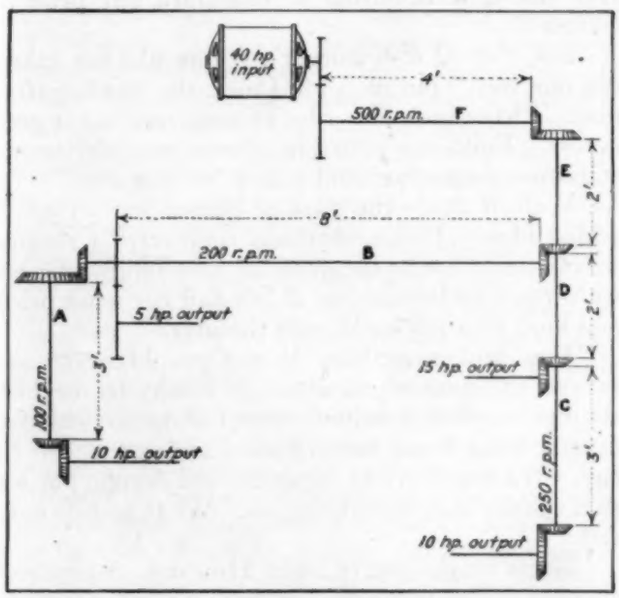
Shortening Labor in Design Calculations

By Alfred Wasbauer

Standardization Engineer, The Ingersoll Milling Machine Company

OBTAINING the rigidity which is so essential in modern machine tools often involves tedious calculations on the part of the designer. In designing the body members of a machine, experience is usually the best guide to proportion and form, but in the design of power-transmitting elements where input and output are generally known, a definite rigidity is obtained by a simple computation.

The first step should be to determine the maximum allowable torsional deflection at the point of power output. This will be based on the overload capacity of the driving motor and conditioned entirely by the nature of the work required of the machine. For instance, a milling machine subject to conditions of pulsating power output will require greater rigidity than a boring machine in which the power output is relatively steady. If the power is applied to a rotating member, the diameter of cut is also an important factor in arriving at



Schematic diagram of method of treating shaft computations

the maximum allowable torsional deflection, since the deviation at the tool will be proportionate to the diameter of the cut. In all cases, the allowable deflection should be determined at the cutting point in inches, then translated into angular values, preferably minutes of the circle. Each shaft in the drive can then be proportioned according to the following formulas, in which:

2,204—Torsional deflection in minutes per unit foot length for 1-in. shaft transmitting 1 hp. at 1 r.p.m.

D—diameter of shaft

R—r.p.m.

H—horsepower transmitted

M—allowable torsional deflection in minutes at output

L—Distance in feet between input and output

then: $\frac{D^4RM}{2{,}204\,L} = H,$ and: $\sqrt[4]{\frac{2{,}204\,HM}{RL}} = D.$

Example—What horsepower will a 3-in. shaft transmit for a total deflection of 45 minutes? The shaft runs 100 r.p.m. and the distance is 15 ft. between input and output:

$$H = \frac{D^4RM}{2{,}204\,L} = \frac{81 \times 100 \times 45}{2{,}204 \times 15} = 11 \text{ hp.}$$

Example—What size shaft is required to transmit 25 hp. at 80 r.p.m. over a distance of 30 ft. with a torsional deflection of 20 minutes?

$$D = \sqrt[4]{\frac{2{,}204\,HM}{RL}} = \sqrt[4]{\frac{2{,}204 \times 25 \times 20}{80 \times 30}} = 4.6 \text{ hp.}$$

When the drive branches off to a number of outputs, each is to be treated as a separate drive. For instance, in the accompanying schematic diagram:

Shaft *A* will have the characteristics of a 10 hp., 17-ft. drive at 100 r.p.m.

Shaft *B* will have the characteristics of a 15 hp., 14-ft. drive at 200 r.p.m.

Shaft *E* will have the characteristics of a 40 hp., 6-ft. drive at 250 r.p.m.

Other shafts are treated similarly in computations for shaft characteristics by merely repeating the process indicated.

Practical Contact for the Designer
Discussion

By Morton Schwam

IN MY opinion, the remarks of Wm. F. Kunz in the *American Machinist*, Vol. 71, page 246, concerning the practical contact of the designer with the shop, exaggerate the value of such contact for the draftsman working for a small concern. A designer with a large concern employing 30 to 40 draftsmen acquires a better knowledge of shop practice and methods than one with a smaller concern for the simple reason that the duties of the chief draftsman of the larger concern do not permit him to take up questions which arise in the shop. If the shop raises a question about a design, the chief draftsman of the large concern refers the question to the draftsman who made the drawing. In that way the draftsman learns, first hand, the difficulties the shop has encountered, and in the future will try to avoid them, whereas, the chief draftsman of a small concern handles all such problems and the under draftsman is not consulted.

Draftsmen working for the large concern have an advantage because such a concern usually has more projects on hand than the smaller concern. In consequence individual draftsmen are shifted from one project to another, again gaining more practical contact with the shop than if they were draftsmen with a smaller company.

THE ENGINEERING C

The scene is a big contract production shop, consolidated also with an iron foundry and a nonferrous metal plant. It controls, also, a smaller shop that makes a specialty of contract production for the chain stores and mail-order houses. Conferences of the engineering and affected production executives with the chief engineer have grown into what the plant calls "The Engineering Council," which meets in a "council room" in the engineering department. Foremen are called in, and others drop

When Sales Take a Slump

"WELL, boys," said the general manager Howard Hedly, "I guess you all know that sales of our oil burner have taken an awful slump. Two years ago our product looked at least as good as any burner made. Sales were O.K. and prospects bright. Today that's all changed. Yet designs we considered far inferior to ours have gone over big. Service has cost us a pretty penny. I'm not trying to lay blame on anybody, but we've got to know why we're running into red ink, so the same mistakes will not be made again. Let's hear from the sales department first."

"Nobody'll like what I've got to say," responded the genial sales manager, Ray Sellers, "but there's no use mincing matters. Cream's all gone in this business. Simply can't sell a burner that costs more to install and more to service than the thing's worth. Also, our burner's too noisy and too complicated. Some gadget's always out of order."

"What do you expect when they never oil or clean anything?" put in Arthur Levering, the chief engineer. "They let 'em set and rust all summer and then kick because everything isn't O.K. the first cold day. Could be made cheaper to build and cheaper to install, but we set out to design a high-grade job. It certainly worked fine in our tests."

"It sure did, Art," chimed in superintendent George Overman. "Costs something to build, but I guess everybody don't appreciate fine work. Otherwise they'd give the job some care when they got it. Can't blame Art for high cost of installation, or noise, either. The underwriters have to be satisfied, and that costs money. Folks ought to close in their furnaces better if noise bothers 'em."

"There you go again, George," shot back Fred Wright, service engineer. "Adding another hundred to the cost by closing in the furnace would be a big help just now, wouldn't it? Why not build a burner that's quiet to begin with? Ought to hear what some of our customers say about noise! Why even the Q & K burner at one third our price is quieter."

"Say, that Q & K burner's selling like hot cakes out our way," put in Andy Lines, the chief draftsman. "May look like a lot of cast iron, but it gets across. Folks can afford it. Some even do the installation themselves and save a lot that way."

"Well, if that's the class of burner we can sell," added Henry Howe, methods engineer, "I reckon we can build 'em as cheap as the next fellow. Guess we slipped up because we didn't find out what price and kind of a job would suit the user."

"You said something that time, Henry," answered the general manager. "Looks to me like all our troubles resulted from failure to find out exactly what home owners want and can afford to buy. We may have to scrap the old design, but we won't make that mistake again. What you do say, Art?"

"Guess maybe you're right, Howard. A new and cheaper design may save the day. Only I hope you won't hold this bust against the engineering department. We did our best with the information we had. Any way we can get into the field for some first-hand dope?"

"You bet there is, Art. You'd better figure on spending at least one week a month mixing with our dealers and customers, and have one or more men from your department in the field all the time. That'll keep you posted on what's wanted and also on what competitors are doing. Then we won't be caught napping again."

How can designers keep in active contact with consumer's requirements? In what ways is this problem solved effectively?

G COUNCIL

in. The problems are not solved for the readers, but some of the opposing opinions are brought out. Engineers and designers are invited to discuss the problem, or to present new problems for discussion. Acceptable letters are paid for at regular rates.

DISCUSSION OF COUNCIL TOPICS

Who Should Design Patterns?

WHEN considering the design of a pattern the foundry viewpoint is probably the most important and should be given most careful consideration. The foundry superintendent should be consulted freely and his ideas given full weight. But the actual work of designing the pattern should be done by a particularly competent patternmaker, usually one with experience in the particular kind of work under consideration, and also familiar with foundry methods. His chief work, in a large shop, consists of laying out on a board a full-size drawing of the pattern, allowing for shrinkage, and showing machining allowances. The layout also shows the size and location of core prints, position of loose pieces, position of parting line, and such other details as instructions to aid the molder in setting cores correctly.

The engineering department should design the casting as they want it to be. It is the foundry's part to produce good castings. The patternmaker's job is to provide suitable pattern equipment. Such equipment does not mean the cheapest, but that which will enable the foundry to produce castings acceptable to the engineering department, and to produce them most economically.

—JOHN GODDARD, *Experimental Engineer, Frost & Wood Company, Ltd., Little Falls, Ontario.*

A LARGE automobile plant, which had both a foundry and pattern shop, was confronted at one time with a tangle, supposedly caused by improper patterns. The designer prepared drawings for any part requiring machine work and left the dimensioning of the pattern itself up to the patternmaker. Even though the patternmakers used but one class of shrink rule for a particular material, slight variations between different men's work continually occurred.

In one case six piston patterns grouped on a match plate were made by two men. The weight of Lynite castings from the patterns made by one man was found to be ¼ lb. more than that of castings from patterns of the other patternmaker. As this extra weight multiplied by the number of castings represented a large and unnecessary loss, a thorough study of the situation was made, and a similar loss found to occur in many patterns.

It was decided that a skilled patternmaker should be assigned to contact with the foundry, pattern shop, and drawing office, and that two fairly experienced draftsmen should be placed under his supervision. They secured all drawings on which there were pattern details and dimensioned them in such a way that the proper shrinkage was added and the drawing all ready for the patternmaker to work from. The patternmaker then could make the pattern from a blueprint without ever using the shrink rule. In this way very few errors crept into the patterns, and there was always a proper wall thickness and weight. When trouble occurred in the foundry the contact man was right on the job, and after analyzing the difficulty the necessary corrections would be made and the work resumed. This plan worked successfully and at the end of a year a first-class department, covering pattern design and inspection and consisting of the contact engineer as supervisor, three designers, one design checker, and two pattern inspectors, was organized. This arrangement permitted three checkings before a pattern reached the foundry, and resulted in a considerable reduction of spoilage and a decrease in expense.

Further benefits resulted when the best books obtainable on pattern and foundry work were provided to educate the men of the department. Whenever possible, the contact man visited other foundries, and he brought home many helpful ideas. Where the spoilage in some foundries runs as high as 15 per cent, this foundry is averaging but 3 to 5 per cent and only a very small percentage of this loss is due to improper patterns or cores.

Care must be taken, when starting this system, to see that a man of the right type, one who has had considerable founding and pattern experience and who possesses a good theoretical background, is placed in charge of the work, as otherwise trouble will be encountered.

—F. A. J. SCHMIDT, *Industrial Engineer, Western Electric Company.*

MACHINE and tool designers should have sufficient knowledge of pattern making and foundry work to be able to avoid unnecessary cores and loose pieces on patterns. The cooling of metals should also be understood so that thick sections will not cause adjacent thinner ones to crack. The need for proper fillets and the use of chills also should be understood.

Patternmakers should determine the best setting for ordinary cores and make core boxes accordingly. Metal patterns and gated patterns for the squeezer board usually can be made without consulting other departments.

Foundrymen know the best position for parting, pouring, location of vents, quality of sand, and whether gaggers are necessary. In the case of balanced cores and three-part flasks the patternmaker and foundryman should get together, and if chaplets are necessary to support the cores the designer should be consulted, for he may have in mind some attachment for the machine at points where the chaplets would interfere. The duties of all of these men overlap more or less, and a working knowledge of the other's problems is a valuable asset to each.

The patternmaker is the best pattern designer, for certainly the blueprint of a part with pattern dimensions is hardly more than a detail.

—J. A. POTTER, *Chief Draftsman, Singer Manufacturing Company, Bridgeport Plant.*

Conical Spring Design

Some New Facts and Formulas

By Joseph Kaye Wood
Consulting Engineer

RECENT developments in the design of helical springs, in which ample proof is furnished of inaccuracies in the standard handbook formulas, to the extent of 60 per cent under maximum conditions, makes it imperative to modify present conical spring formulas. The conical spring is similar in certain respects to the helical spring. Some newly discovered and experimentally confirmed facts have been used in the modification of helical spring formulas, and these facts can be applied in modifying conical spring design. To assist those not familiar with current practice, a brief review of the derivation of present formulas is given.

If a piece of elastic wire is wound on a cylindrical arbor so as to form a helix, similar to a machine screw thread, the resulting structure is termed a helical spring, while if the wire is wound on a conically shaped arbor so as to form a composite helix and spiral, similar to a wood screw thread, the resulting structure is termed a conical spring. In the interest of correct nomenclature, it should be noted that a helical spring is so called because of the mathematical curve to which the wire conforms. This method is not followed in the case of a conical spring, which is so called because of the shape of the arbor used or because of the over-all shape of the formed wire. The error is commonly made in practice of calling a helical spring a "spiral" spring. Since there is absolutely no suggestion of a spiral curve in a helical spring, this erroneous habit should be avoided.

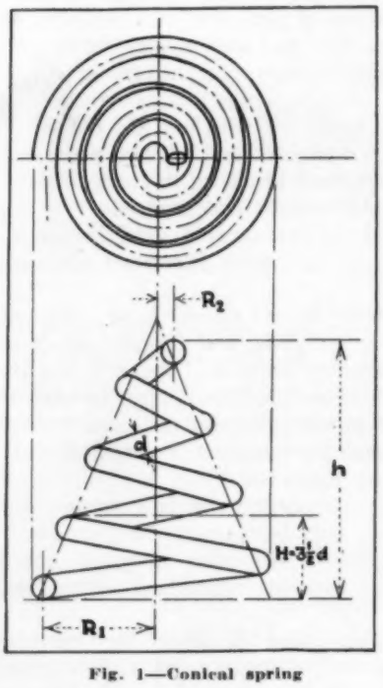


Fig. 1—Conical spring

A helical or conical spring may be loaded so as to increase or decrease the axial length, in which case the wire is stressed principally in torsion. In practice, a conical spring nearly always is used as a compression spring. On the other hand, either a helical or conical spring may be loaded torsionally with respect to the spring's axis, in which case the wire is stressed principally in flexure. A conical spring is seldom used in this manner, however. This article deals only with conical and helical springs loaded axially.

The wire in a conical spring conforms to a curve that is a composite of the helix and spiral curves. Mathematically, the spiral is nearly always of the Archimedes type because of the equal spacing of coils. There is an important reason, however, why the coil spacing of a conical spring should be graduated, but in this article only equally spaced helical coils, which can only conform to the Archimedes spiral, are considered. Fig. 1 depicts a conical spring of this type, the plan view showing the elements of the spiral and the elevation showing the "conical" effect which the Archimedes spiral has on the helix when the two are combined.

By bearing in mind the mathematical properties of the helix and spiral curves, the derivation of the conical spring deflection formula becomes quite simple:

a—The helix or screw thread curve, Fig. 2, crosses planes perpendicular to the axis $o - o'$ at a constant angle V. For this reason, the height h of a helical spring, whether loaded or not, is proportional to the tangent of the angle V which may be expressed symbolically as follows,

$$h = 2\pi R_1 n \tan V = \alpha R_1 \tan V \qquad (1)$$

in which R_1 is the constant mean radius of the coils, n is the number of coils and α is the horizontally projected angle, in circular units, swept out by the complete helix. If we let H equal some fixed height, say nd, where d is the diameter of spring wire, then $\tan V$ equals $H \div 2\pi R_1 n$ which, when substituted in (1) gives,

$$h = \frac{H}{2\pi n}\alpha$$

from which,

$$\delta h = \frac{H}{2\pi n}\delta\alpha \qquad (2)$$

$\delta h \div \delta\alpha$ being the rate of increase of h with respect to α.

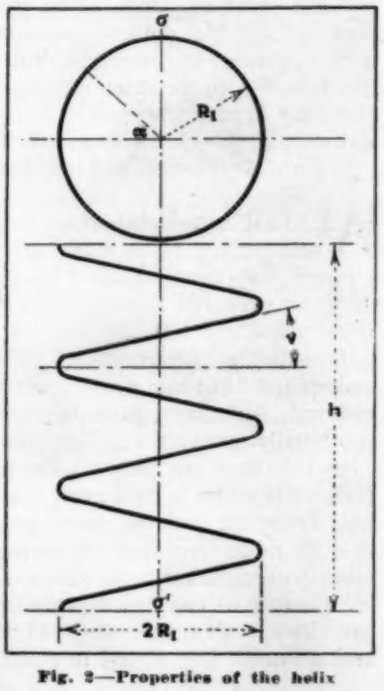


Fig. 2—Properties of the helix

b—In the Archimedes spiral, Fig. 3, the radius R is proportional to the angle swept out, and,

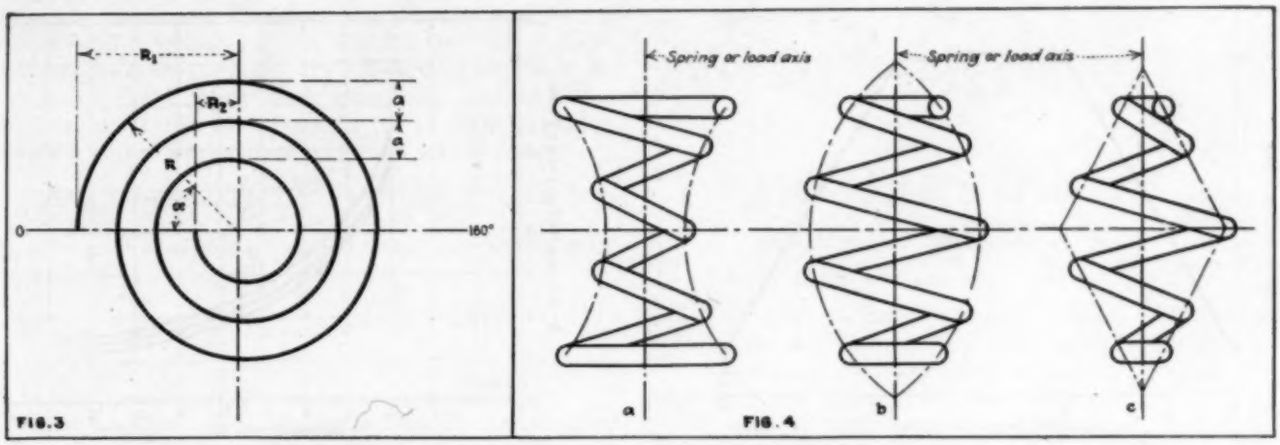


FIG. 3 FIG. 4

Fig. 3—Properties of the Archimedes spiral. Fig. 4—(a) hour-glass, (b) barrel-shaped and (c) diamond-shaped springs, which, in common with the conical springs, belong in the helix class of springs

in the case of a spiral spring,

$$R = R_2 + k\alpha = R_2 + \frac{a}{2\pi}\alpha \qquad (3)$$

in which α is measured in circular units, and a is the spacing between coils. It should be noted that $an = R_1 - R_2$ where n is the number of coils. We, therefore, may write,

$$R = R_2 + \frac{R_1 - R_2}{2\pi n}\alpha$$

or differentiating and transposing,

$$\delta\alpha = \frac{2\pi n}{R_1 - R_2}\delta R \qquad (4)$$

c—Substituting α as expressed by (4) in (5) combines the helix with the Archimedes spiral resulting in the conical spring, Fig. 1. Accordingly,

$$\delta h = \frac{H}{R_1 - R_2}\delta R \qquad (5)$$

in which H, R_1 and R_2 are fixed or constant quantities.

With these geometric facts concerning the helix and spiral curves, or their combination, before us, we can proceed to develop the deflection formula for the conical spring. For this purpose, the height of the spring is considered as being divided into an infinite number of parts or helical springs, each equal to δh in height but with a different radius. The flexibility of each one of these elementary springs is equal to,

$$\delta F = \frac{64PR^3}{Gd^5}\delta h \qquad (6)$$

in which R is a variable.

All of these elementary springs act in series with each other, and, since it is well known that the combined flexibility of several helical springs, acting in series, is equal to the sum of the flexibilities of the individual springs, then the total flexibility of the conical spring is equal to the summation of the flexibilities of all the elementary springs, that is,

$$F = \int \frac{64PR^3}{Gd^5}\delta h \qquad (7)$$

and since R is a variable, it is necessary to substitute for δh its value in terms of δR. Accordingly, substituting (5) in (7) we obtain,

$$F = \int \frac{64PR^3}{Gd^5}\frac{H}{R_1 - R_2}\delta R$$

Integrating between the limits of $R = R_1$ and $R = R_2$ (see Fig. 1),

$$\begin{aligned} F &= \frac{64P}{Gd^5}\frac{H}{R_1 - R_2}\int_{R=R_2}^{R=R_1} R^3\delta R \\ &= \frac{64P}{Gd^5}\frac{H}{R_1 - R_2}\frac{R_1^4 - R_2^4}{4} \\ &= \frac{64P}{Gd^5}\frac{H}{R_1 - R_2}\frac{(R_1 - R_2)(R_1 + R_2)(R_1^2 + R_2^2)}{4} \\ &= \frac{64PH}{Gd^5}\frac{(R_1^2 + R_2^2)(R_1 + R_2)}{4} \end{aligned} \qquad (8)$$

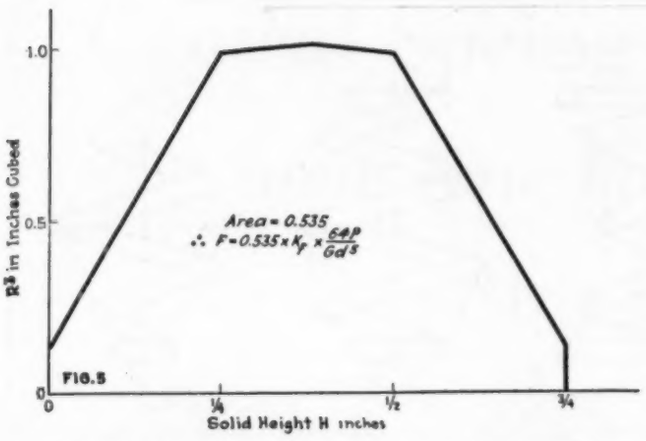
which is the present standard formula for the deflection of equally coil-spaced conical springs. Load is represented by P and torsional modulus of elasticity by G.

A short-cut method used by spring specialists in designing springs of these types is shown in Fig. 4, in which the variation of the radius conforms to profiles other than that of the conical spring. In this method, which is based upon formula (7) the solid height H is laid off on a horizontal axis. At equal divisions of this height, the corresponding values of R^3 are laid off on verticals erected at these points. The area enclosed by the curve joining these points and the horizontal and vertical axis multiplied by $64K_fP$ and divided by Gd^5 gives the value of the deflection. Fig. 5 shows this type of graphical solution for the barrel-shaped spring illustrated in Fig. 4 *b*. In this manner the deflection of helically-coiled springs of any profile may be determined.

The derivation of the standard handbook maximum stress formula is much simpler than that of the deflection formula, because the former is concerned with a condition at only one point in the spring, that is, the point of maximum intensity of stress, while the latter is concerned with a cumulative effect of conditions at all points in the spring. The following formula,

$$S_{max.} = \frac{16PR}{\pi d^3} \qquad (9)$$

applies to helically coiled springs irrespective of external profile which may be straight as in helical springs or conical as in conical springs, or shaped in any manner such as illustrated in Fig. 4. The only thing to bear in mind is that the point of maximum stress will be where the radius R is maximum. In the specific case of the conical spring, this point would be where the radius is equal to R_1.



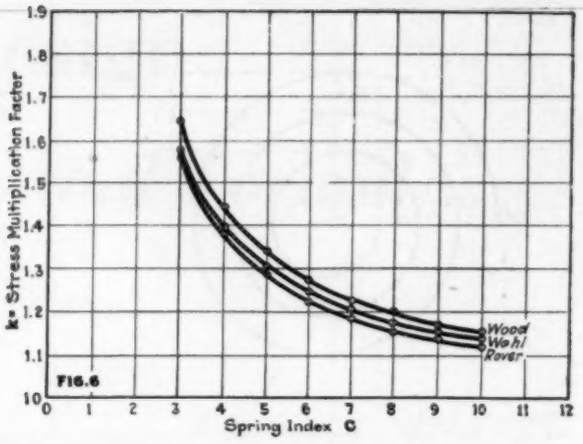


Fig. 5—Graphical determination of deflection F, of the spring shown in Fig. 4 (b). Fig. 6—Variation of stress-formula "constant," k, (old practice) with spring index, c

Spring specialists have known for many years that helical springs with low indexes (ratio of coil diameter to wire diameter) were actually stressed considerably beyond the point indicated by formula (9). This discrepancy was accounted for to some extent by the fact that the vertical shear, which is neglected in the derivation of formula (9), becomes quite appreciable when low indexes are used. For example, the vertical shear in a helical spring having an index of 3 is equal to 16 per cent of the regular torsional shear, while, in a helical spring having an index of 8, the vertical shear is equal only to 6 per cent of the torsional shear. This increase in stress, however, was insufficient to account for breakages occurring in service, and, consequently, it has been considered good design practice to avoid indexes less than 5 and preferably to keep them less than 7. In cases where low indexes have been unavoidable, due to space and other limitations, the best practice has been to calculate with unusually low stresses, that is, to use a considerably larger factor of safety.

In an article entitled "Beanspruchung Zylindrischer Schraubenfedern mit Kreisquerschnitt" (Zeitschrift des Vereines deutscher Ingenieure, 1913, p. 1907(Rover published the results of his theoretical investigation of stresses in helical springs of low indexes. This seemed to account fully for the discrepancy between calculated and actual stress values. His correction factor k, which is a function of the index only, was based upon the consideration of the two following facts:

a—The vertical shear becomes appreciable for small indexes. As stated previously, this fact had been generally known and allowed for in the design of helical springs. This source of correction accounted for about 30 per cent of Rover's correction factor k.

b—The other source of correction consisted of a discovery for which Rover probably should be credited. He found that, for a given angle of twist, the fiber on the extreme inner side of the coil is very much shorter than the fiber on the extreme outer side of the coil, which gives rise to differences of appreciable magnitude in the unit deformations for those fibers.

The formula which Rover derived is:

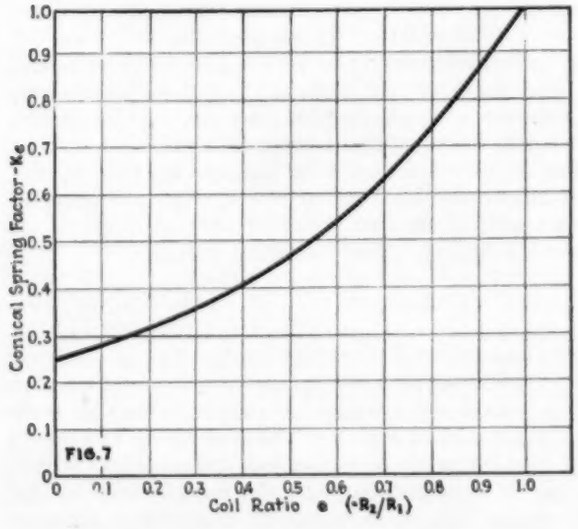
$$S = k \frac{16PR}{\pi d^3} \qquad (10)$$

in which k is the correction factor, its value being expressed as follows,

$$k = \frac{c}{c - 1} + \frac{1}{4c}$$

in which c is the index or $2R \div d$.

Formula (10) was not generally adopted for a time. due to lack of experimental confirmation which finally



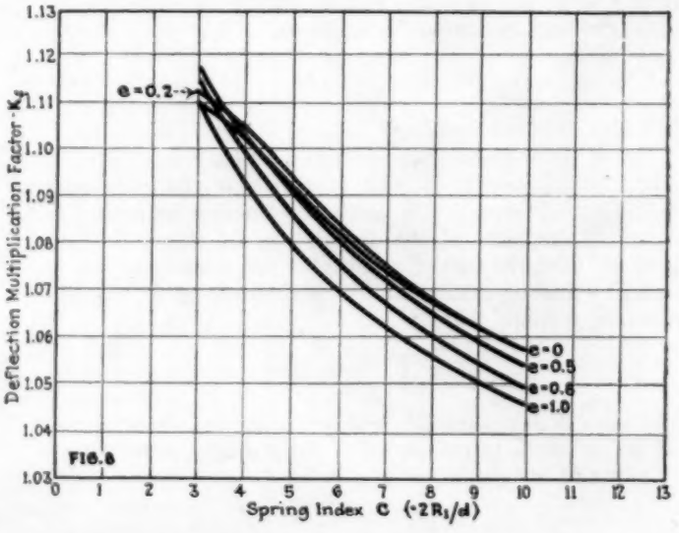


Fig. 7—Variation of conical spring factor, K_c with coil ratio e. Fig. 8—Curves giving different values of the ratio e

was provided by A. M. Wahl and presented in a paper "Stresses in Heavy Closely-Coiled Helical Springs" at the Annual Meeting of the A.S.M.E., Dec. 3 to 7, 1928. Rover's theoretical results agreed very closely with the results of Wahl's tests, there being only a slight differenct in their forms of expression for k. Wahl's expression for k, the "multiplication factor," was as follows:

$$k = \frac{4c - 1}{4c - 4} + \frac{0.615}{c} \qquad (11)$$

In a discussion of this paper, the writer provided a value of k equal to,

$$k = \frac{c}{c - 1} + \frac{1}{2c} \qquad (12)$$

From a plot of these three expressions of k in Fig. 6 it is seen that the difference is inconsequential.

Since modification of the stress formula should affect the deflection formula also, although to a much lesser extent because of the accumulative character of this formula, the writer in his discussion of Wahl's paper derived the following modified formula for the deflection of helical springs,

$$F = K_f \frac{64PR^3H}{Gd^5} \qquad (13)$$

in which $K_f = \frac{2c^2 + c - 1}{2c^2}$. The writer called K_f the deflection multiplication factor. Fig. 8 shows a plot of the factor K_f for different values of the index c ($e = 1$).

It is the principal purpose of this article to derive a new deflection formula for conical springs which will take into account the two sources of correction previously mentioned in connection with the modified formulas for helical springs.

Putting the modified formula (13) into the integral form, we have:

$$F = \int K_f \frac{64PR^3}{Gd^5} \delta h$$

and since from (5) $\delta h = \frac{H}{R_1 - R_2}\delta R$,

$$F = \int K_f \frac{64PR^3}{Gd^5} \frac{H}{R_1 - R_2}\delta R$$

Integrating between the limits of $R = R_1$ and $R = R_2$ we obtain:

$$F = \frac{64P}{Gd^5} \frac{H}{R_1 - R_2} \int_{R = R_2}^{R = R_1} K_f R^3 \delta R$$

and since $K_f = \frac{2c^2 + c - 1}{2c^2} = 1 + \frac{d}{4R} - \frac{d^2}{8R^2}$,

$$F = \frac{64P}{Gd^5} \frac{H}{R_1 - R_2} \int_{R = R_2}^{R = R_1} \left(R^3 + \frac{R^2 d}{4} - \frac{Rd^2}{8}\right) \delta R$$

$$= \frac{64P}{Gd^5} \frac{H}{R_1 - R_2} \left[\frac{R_1^4}{4} + \frac{R_1^3 d}{12} - \frac{R_1^2 d^2}{16}\right] - \left[\frac{R_2^4}{4} + \frac{R_2^3 d}{12} - \frac{R_2^2 d^2}{16}\right]$$

$$= \frac{64P}{Gd^5} \frac{H}{R_1 - R_2} \frac{R_1^4 - R_2^4}{4} \left[1 + \frac{d(R_1^3 - R_2^3)}{3(R_1^4 - R_2^4)} - \frac{d^2}{4(R_1^2 + R_2^2)}\right]$$

$$= \frac{64P}{Gd^5} \frac{H}{R_1 - R_2} \frac{(R_1 - R^2)(R_1 + R_2)(R_1^2 + R_2^2)}{4} \left[1 + \frac{d(R_1 - R_2)\ (R_1^2 + R_1R_2 + R_2^2)}{3(R_1 - R_2)(R_1 + R_2)(R_1^2 + R_2^2)} - \frac{d^2}{4(R_1^2 + R_2^2)}\right]$$

$$= \frac{64PH}{Gd^5} \frac{(R_1 + R_2)(R_1^2 + R_2^2)}{4} \left[1 + \frac{d(R_1^2 + R_1R_2 + R_2^2)}{3(R_1 + R_2)(R_1^2 + R_2^2)} - \frac{d^2}{4(R_1^2 + R_2^2)}\right] \qquad (14)$$

which is the modified deflection formula for conical springs, the expression in the brackets being the correction factor, and the expression outside the brackets being the present standard formula as expressed in (8).

The above formula can be simplified greatly by putting $e = R_2 \div R_1$ and $c = 2R_1 \div d$. Making these substitutions, we have,

$$F = \frac{64PR_1^3H}{Gd^5} \left[\frac{(1 + e)(1 + e^2)}{4}\right] \left[1 + \frac{2(1 + e + e^2)}{3c(1 + e)(1 + e^2)} - \frac{1}{c^2(1 + e^2)}\right]$$

New Formulas for the Design of Round-Wire Conical Springs

DEFLECTION, $F = K_c K_f \frac{64PR_1^3H}{Gd^5}$

in which, $K_c = \frac{(1 + e)(1 + e^2)}{4}$

and, $K_f = 1 + \frac{2(1 + e + e^2)}{3c(1 + e)(1 + e^2)} - \frac{1}{c^2(1 + e^2)}$

MAXIMUM STRESS, $S = k \frac{16PR_1}{\pi d^3}$

in which, $k = \frac{c}{c - 1} + \frac{1}{2c}$

DESCRIPTION OF SYMBOLS

F = Deflection in inches
K_c = Conical spring factor, a pure number
K_f = Deflection multiplication factor, a pure number
P = Load in pounds
R_1 = Maximum or base radius of spring coil in inches
H = Arbitrary height of spring equal to nd in inches
n = Number of active coils in spring
G = Torsional modulus of elasticity in lb. per sq.in. For steel this factor is about 11,800,000 lb. per sq.in.
d = Diameter of spring wire or bar in inches
e = Coil ratio equal to $R_2 \div R_1$, a pure number
R_2 = Minimum or top radius of spring coil in inches
c = Spring index equal to $2R_1 \div d$, a pure number
S = Maximum stress in wire in lb. per sq.in.
k = Stress multiplication factor, a pure number

See curves Figs. 6, 7 and 8 for values of k, K_c and K_f respectively. The deflection formula is valid only when the coils do not touch each other.

Setting the expression in the first pair of brackets equal to K_c and the expression in the second pair of brackets equal to K_f we have,

$$F = K_c K_f \frac{64PR_1^3H}{Gd^5} \qquad (15)$$

When $R_1 = R_2$, making e equal to unity, then K_c becomes unity and,

$$F = K_f \frac{64PR_1^3H}{Gd^5} = \left(\frac{2c^2 + c - 1}{2c^2}\right) \frac{64PR_1^3H}{Gd^5}$$

which is the modified deflection formula for helical springs as expressed in (13). Without K_f we have the present standard handbook deflection formula for helical springs.

The writer calls K_c the conical spring factor and K_f, which also appears in the helical spring deflection formula, the deflection multiplication factor. In Fig. 7 the K_c — e curve is shown while in Fig. 8 a series of K_f — c curves for different values of e are shown. With these two sets of curves and formula (15), the deflections of a conical spring with any degree of taper can be predicted easily.

The modified stress formula for conical springs will of course be the same as for helical springs (see formula 10) in which R_1, the maximum radius, is substituted for R. Any one of the three expressions given for k may be used in this formula, since they all give practically the same results.

Preceding formulas do not take into account a certain amount of flexure which occurs in the wire, even to a greater extent than in helical springs, but the error due to this additional stress is small.

In an accompanying summary is given the new formula and a tabulation of the symbols employed. While the newly modified formulas for the design of conical springs presented in this article have not been tried thoroughly as yet, there is sufficient experimental evidence to warrant their publication at this time. In this manner only is it possible to determine the general practicability of new formulas, even though their derivation depends upon such sound experimental facts as are presented in this case. The author hopes that readers interested in the design of springs will put these newly modified formulas to use and note the results obtained. Records of the results obtained will be appreciated by the editor as well as by the author.

Magnesium and its Alloys

By W. G. Harvey
Aluminum Company of America

MAGNESIUM will alloy with practically all the common metals with the exception of iron and chromium. A large field has been explored by investigators in search of alloys interesting from a structural standpoint, and many valuable facts have been discovered concerning the solubility of the common metals in magnesium, the occurrence of metallic compounds, and the strength and resistance to corrosion of many alloy combinations.

The suitability of heat-treated magnesium-alloy castings for aircraft use is fairly evident when one considers the average tensile strength of 33,000 lb. per sq.in. with 10 per cent elongation in 2 in. in a casting weighing only two-thirds that of an equivalent aluminum casting. The effect of the lower specific gravity is better indicated by calculating the strength—mass ratio or tensile strength in lb. per sq.in. divided by the specific gravity.

Of greater importance than high mechanical strength is the question of the durability of the materials entering into engine and airplane construction. The lack of stability of magnesium in salt water, and even to some extent in fresh water, was a characteristic of the product made some years ago. Metal of inferior quality has been distributed and alloys used in fabricated products which had satisfactory physical properties, but no attention was paid to corrosion resistance. The corrosion of these alloys has produced an erroneous impression of the stability of pure magnesium, or of the good alloy composition. This subject has been given careful consideration in recent years, and has led to the development of particular alloys and compositions with not only high mechanical strength, but also much improved resistance. One of the first steps by which the present satisfactory stability is secured is through careful purification, and secondly, by the addition of certain constitutents that will increase the stability. Manganese is a good example of such a constituent, and it is now added to most of the commercially used alloys.

Magnesium-alloy forgings are a product which will be interesting and useful to aircraft manufacturers. While the casting of magnesium can be considered as definitely commercial, with only the refinements and lower costs to follow with increased production, the making of magnesium forgings has just emerged from the experimental stage. Aircraft propellors, supercharger impellers, pistons, and a number of engine parts have already been made in sufficient quantity to prove the value of this product and to determine the physical properties with accuracy.

Magnesium sheet can be obtained in any gage down to 32 B. & S. The corrosion resistance of rolled sheet is not as high as that of castings. It can, however, be considered stable for all ordinary atmospheric conditions. For use around salt air, some suitable precaution is necessary. Constant progress is being made in the production of sheet with still higher mechanical properties.

Because of high strength and light weight, magnesium castings, forgings and extruded shapes are finding many uses in aircraft. Engines, of course, present many obvious applications, magnesium and its alloys having been used for practically every part from the crankcase to the smallest cover plate. Even magnesium pistons offer many advantages, especially when used in engines with high compression ratios. However, there are still a number of characteristics which must be improved if the magnesium piston is to behave well in an aircraft engine. Research seems well on its way toward solving these requirements, and magnesium pistons, with their great advantage of lightness, will no doubt play an important part in aircraft engine design.

Abstract of a paper presented at the general meeting of the American Electrochemical Society, Sept. 19 to 21, at Pittsburgh.

Design of the Zeiss Planetarium

A Complex Engineering Problem

By Henry Simon

The driving mechanism requires trains of gears in which the ratios of reduction are unprecedented

A SCHEMATIC representation of the complete drive, involving the five motions last described, is given in Fig. 40, while in Fig. 41 is shown a detail plan drawing of the annual and precession drives. The three yearly motors *4*, *5* and *6*, will be seen to impart rotation to the first section J_1 of the shaft over three corresponding sets of planetary transmissions. The resultant ultimate speeds of the solar-system projectors correspond to a year in 7.3 sec., 1 min. and 18 sec., and 3 min. and 55 seconds. This movement is transmitted over a multiple-disk safety coupling J on shaft section K_1, and then over L_1, to the planet line-shafts, the south shaft being driven over an intermediate gear train M_1, and over a smaller shaft H passing through a bore in the precession shaft D. The driving gear and the intermediate gears are plainly seen in Fig. 34, and in Fig 35 the identical matching set of gears upon the face of the opposite precession-shaft flange is visible.

At D_1 a second train is branched off. This train comprises a 13-fold reducing spur-gear train, having a ratio of 1 to 3,000, and ends in a worm T_2 driving a large worm wheel W_2 fast on the precession shaft. This worm wheel W_2 is seen in position in Fig. 39. The large spur gear above it is free on the shaft, and is merely an intermediate for transmitting motion from the final gear of train section L_1 to a small spur gear on the same shaft with the outer of th three gears composing the train denoted by M_1 in Fig. 40, seen also in Figs. 34 and 35. When the precession movement is run off in 1½ min., worm gear W_2 is driven direct from motor *7*. In Fig. 41 is shown the manner in which this double action upon a common worm is accomplished without the use of clutches.

The final link of the "yearly" precession drive is a miter gear K. Facing this gear is a similar gear M fastened to the wormshaft. Connecting both gears is a third miter gear S held on an arm fixed upon a shaft passing through the worm shaft and connected with the fast precession motor *7*. When this motor is turned on, gear S revolves with the shaft and the resistance of the slow gear train causes gear S to run over gear K thereby revolving gear M and, with it, the worm shaft. When gear K is revolving, on the other hand, gear S revolves only around its axis, thereby causing the revolution of gear M and the external worm shaft of which it is a part, but leaving the internal shaft J_2 at rest.

The two motors *2* and *3* form the diurnal movement on the opposite half of the gear-case driveshaft section K_2 in a similar manner over planetary gearing, the ultimate speeds of rotation around axes *1-1* and *2-2* corresponding to a day in 1 min. and 22 sec., and 4 min. and 5 seconds. The drive goes over a shaft section to a worm gear W_1. As has been mentioned, this worm gear is fastened and stationary in relation to the central pivotal frame A. The revolution of the worm thus causes the rotation of the entire instrument whenever one of the two motors *2* and *3* is running. From this movement motion is retransmitted by a large bevel gear T, practically integral with gear W_1, to a pinion V which imparts its movement over lines S_2 and T_4 to shaft J_1 in the north half of the gear case and thereby over K_1

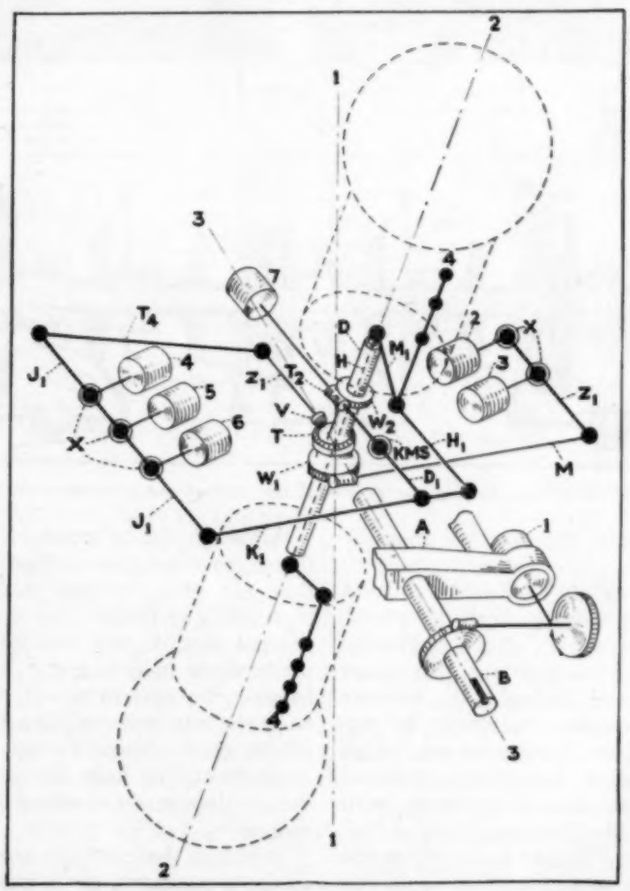


Fig. 40—Schematic perspective of complete Planetarium-instrument drive involving the five motions

The third and final part of the article.

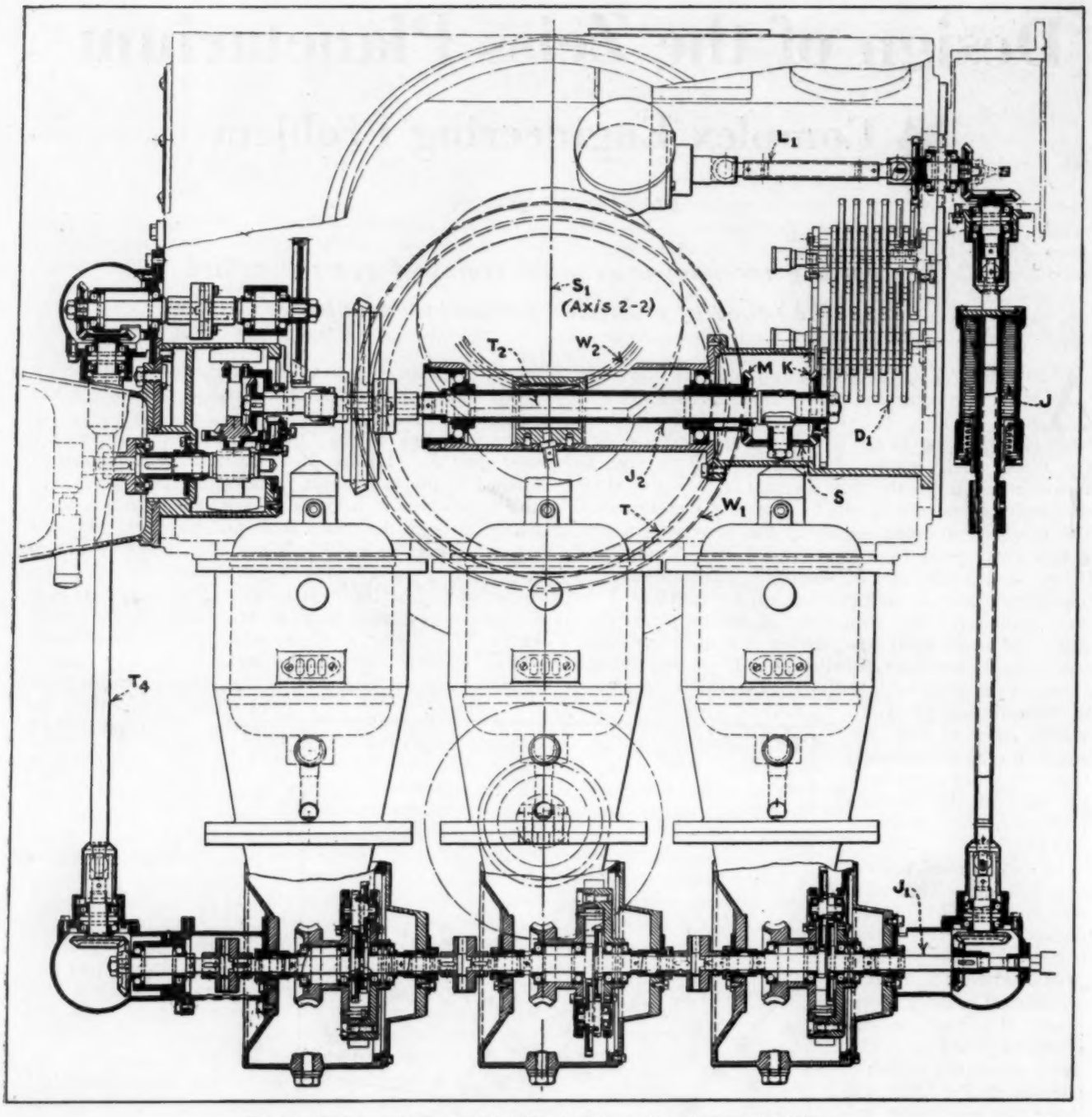


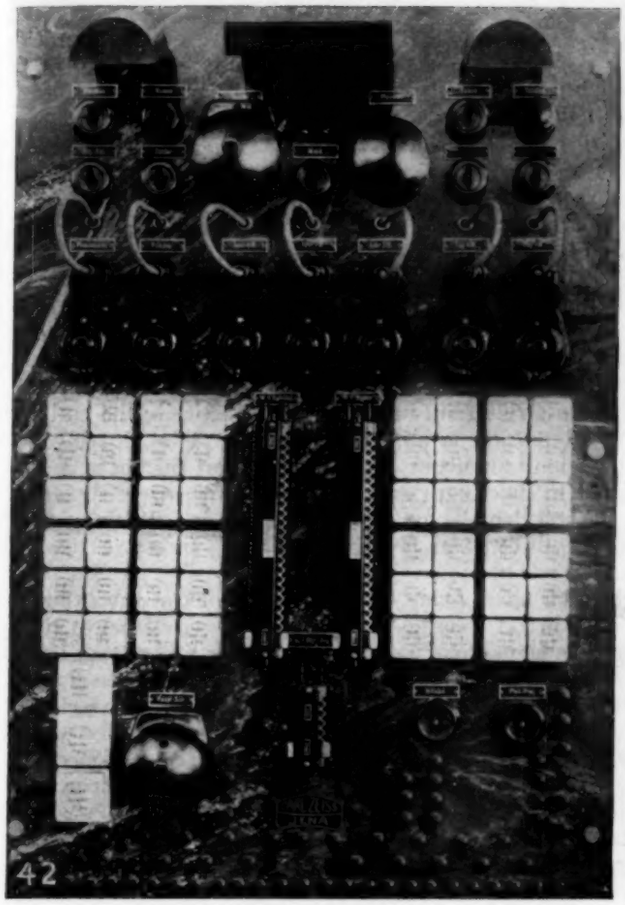
Fig. 41—Drawing showing the details of the annual and precession drives

and L_1 to the solar lineshafts and the slow precessional drive.

It will thus be seen that when any of the two diurnal or the three annual motors are running, both the planet lineshaft *4-4* and the precession shaft *2-2* are revolving. The resulting gear ratios, in respect to the precession drive, are enormously large and undoubtedly without any near precedent. The smallest reduction to the precession axis, from the 7.3-sec. yearly motor, is as 4,320,000 to 1. With the 4-min. motor, this rises to 145,500,000 to 1. And by the roundabout drive from the diurnal motor *3*, there results the stupendous reduction, in exact figures, of 53,192,797,080 to 1. With the motor making 1,380 r.p.m., it would have to run day and night for 74 years before the instrument had revolved around axis *2-2* once.

Although the precessional movement resulting under this last-named ratio is logically correct, it must be plain that any such colossal gear reduction cannot be any more than incidental. It results in connection with the diurnal motion, not because it is desirable to have the precessional motion going on simultaneously with it, but because the movements of the solar-system bodies must be taken into account even in a single diurnal revolution of the earth around its axis, while on the other hand it is necessary to keep the solar-system and precessional drives always interconnected for purposes of the annual motion.

It is true that with the annual motion, the higher ratios in the precessional drive would be of practical value only under exceptional circumstances. At the ratio of 145,500,000 to 1, the motor driving the slowest annual



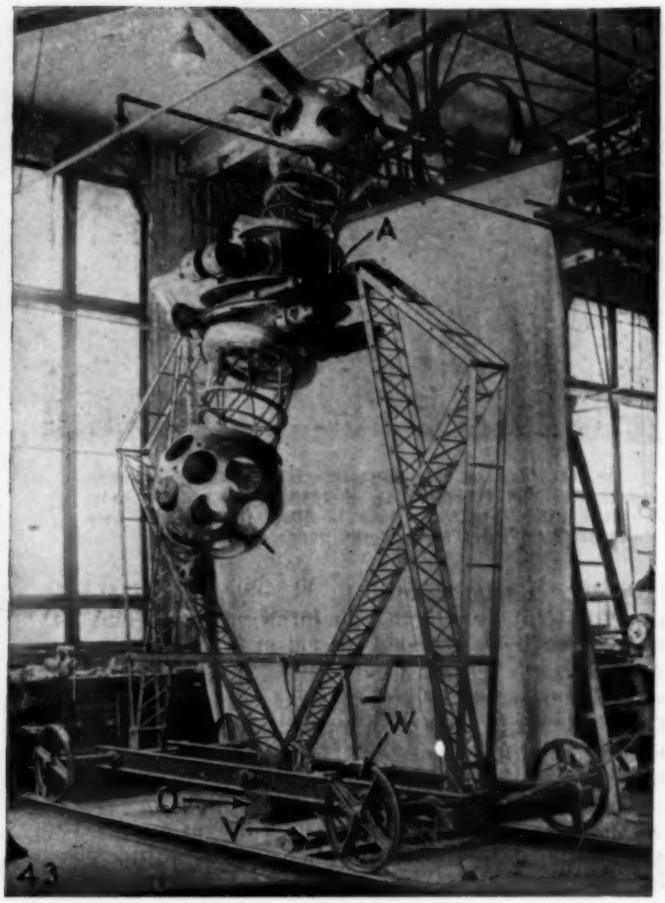


Fig. 42—Control of the instrument is centered in this switchboard, which is placed in front of the lecturer. Fig. 43—Planetarium instrument mounted on a frame for a test. The frame consists of two "scissors" trusses

gear would have to run for six hours before the pole star had changed its position by one degree. Here again, the reason for the precessional movement is that all three of the annual gears necessarily drive the same shaft, and that with the 7.3-second motor, the precessional movement is an absolute necessity.

With this last motion, the instrument need be run but ten minutes before the pole star would have shifted its position by a full degree. This would represent a lapse of only about 70 years in time, while it will undoubtedly sometimes be desired to show historical periods distant by hundreds and even thousands of years, as for instance, at the time of the birth of Christ.

Electrical current for the motors and lamps is supplied by means of sliding contacts of several forms. Current of different voltages enters the instrument over a general distributor *N*, seen in Figs. 34, 35 and 36 on the end of the central-frame axle *B* opposite the motor. This distributor consists of 32 parallel brass disks on the outer stub axle, together with the two opposed sets of sixteen sliding "riders" held upon studs fixed in relation to the central frame. The distributor disks are spaced by insulating washers. Current is introduced over bus wires that pass through matching clearance holes, formed in the disks, into a threaded hole in the terminal disk, there being one such hole in each disk. The bus wires are threaded into these terminal holes, and are anchored by thin counternuts.

From the general distributor, some of the leads run to the motor on the pivoted frame. The remaining leads pass on to the two large distributor disks H_1, shown in Figs. 34 and 37. Each of these disks has twenty concentric brass-strip rings held by six radial sets of slotted chairs, and the same number of intermediate radial insulating strips. Current is taken from these strips by an inner set of "riders" for distribution to the motors and projectors on the two halves of the gear case. A second, double-faced rider set *O*, fastened to each half of the gear case, transfers the current from the outer ring sets of the distributors on the frame to the corresponding rings upon the inner face of each precession-shaft flange. The double-faced transfer set and a portion of the distributor on the precession-shaft flange are seen in Fig. 35. From these last distributors, current is derived for lighting the solar-system projectors, the star-image carriers, the ball-shaped constellation projectors on the end of the latter, and the Sirius and Milky-Way apparatus. To these points, the current is brought by way of varnished busbars spaced peripherally around the solar-system cages. Current for the individual revolving instruments is taken by means of a clip, clamped to a bared spot on the bus wire, through a cable to a leaf spring, fastened to the cage partition, thence to the periphery of a receiver disk in the revolving instrument body, and thence again, by a short flexible cable, to the lamps inside the instrument.

The current used in the various parts of the instrument is of three different voltages. Alternating current of 110 volts is used for the seven motors and the two large fixed-star lamps. Current for the small, ball-shaped

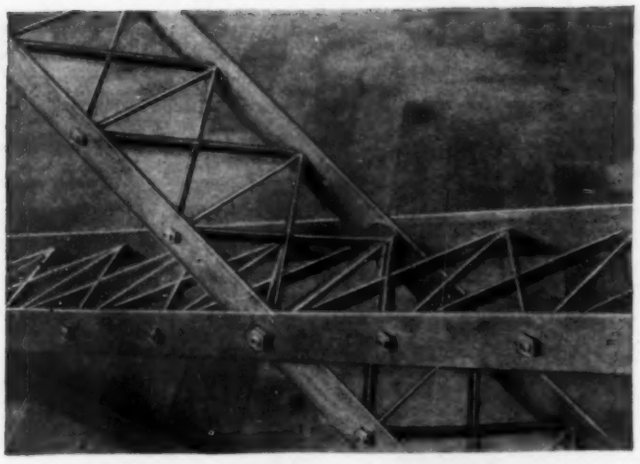


Fig. 44—Close-up of compression members of instrument frame. The crossbars are welded at the middle only. They have notches at ends to allow the bolts to pass through to fasten them to the flange strips

projectors is stepped down to 30 volts by a 1,000-watt transformer. Two more transformers, of 100 and 200 watts respectively, provide current at 6 volts to the two 10-watt lamps for Sirius and the Milky Way, and to sixteen lamps for the seven solar-system instruments. Control is centered upon a switchboard in front of the lecturer, shown in Fig. 42. The total current consumption is 4 kw. for the entire instrument.

The fact that no existing type of lamp had a filament of suitable shape presented a difficulty at first. The theoretically ideal source of light would be in the shape of a single point. After some experiment the Osram Company succeeded in developing a type of lamp having a sufficient degree of concentration and presenting an intense light zone of roughly equal area and shape from every angle. The instrument throughout is now equipped with this type of special lamp.

One of the minor problems was the provision of a suitable framework in which to hang the instrument. Off-hand this would seem a comparatively trivial task. Some inkling of the reasons why this was not altogether so, may be had by remembering the imperative necessity for guarding against the possibility of obstruction of the light rays proceeding from whichever head of the instrument happens to be below the horizon line. This made it necessary to avoid the use of any but the thinnest members. When it is further considered that even a relatively slight vibration of such a frame would result in a visible trembling of the image upon the 80-ft. diameter dome, and that the instrument itself weighs nearly a ton, it will be clear that such a framework must represent the absolute maximum combination of strength, rigidity, and small size in every dimension of each individual member.

A general view of the frame is seen in Fig. 43. It consists of two "scissors" trusses, standing on end and united at the bottom, with the axis of the instrument's central frame closing the gap at the top. The outer, tension members are of the plain ladder type, while the four inner compression members are of latticed construction. The sides of all these members are made from $\frac{7}{32}$x2-in. flat, cold-rolled steel. The entire truss rests upon a rugged channel-iron base which constitutes the third tension member while the central frame *A* of the instrument forms the third compression member.

The real problem in the construction of the carriage frame was that of finding a form of latticework for the four compression members which would not only be stiff enough at a very small relative width, but which would have individual bracing members as thin as possible. The type of latticing shown in Fig. 44 was developed for this purpose. It consists of compression members in the form of crosses welded from machine steel, each of which "toes" against its neighbor at each side. Tension bolts pass through bores formed in the adjacent feet of each pair of crosses.

In this manner the tension bolts lock the crosses and positively hold them against displacement in any sense, while the combination makes the thinnest conceivable joint at the junction of the three members. The tension bolts are about $\frac{3}{8}$ in. in diameter. Practically the entire exposed portion is milled away at the sides, leaving a flat section only about $\frac{5}{32}$ in. thick. This thickness is so related to the length and strength of the screw threads on the bolt that elongation of the bolt body will take place and the thread end be reached before excessive strain could be put upon it as might easily happen in tightening up so many closely-spaced bolts in succession.

The correct location of the instrument relative to the dome, as shown in Fig. 43, is insured by a centering bolt *W* at the bottom, which engages a socket in the floor. When this bolt is engaged in the socket, the intersection of the three main axes of the instrument coincides with the geometrical center of the dome. For convenience in moving and replacing the instrument, the wheels run on rails, one of which is grooved for the flanged set of wheels on one side. This movement of the instrument gives access to the stationary part of a divided knife switch *N* located in a small pit underneath the floor. With the instrument locked in position, this pit is completely covered by the box-shaped guard *O* on the bottom of the carriage, which houses the instrument end of the switch.

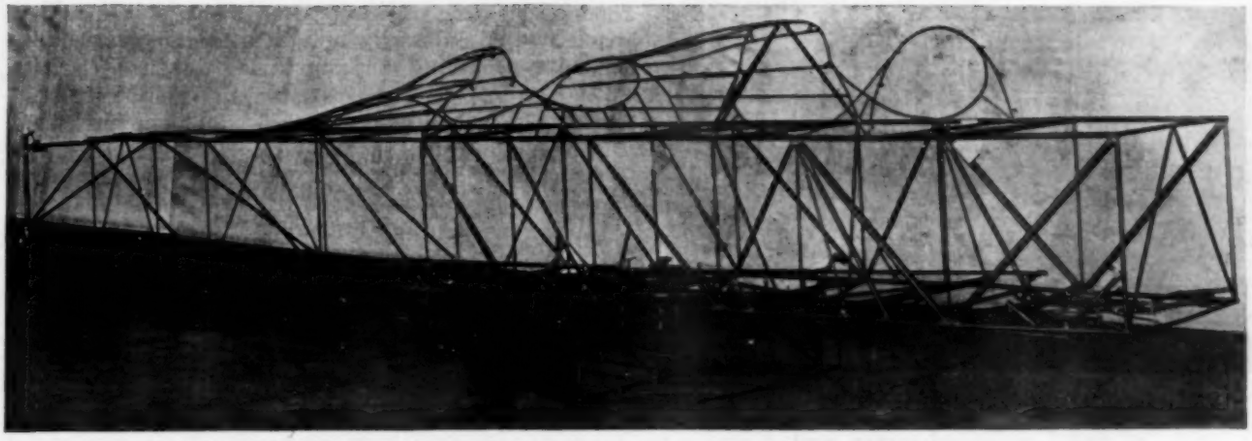
Keeping a Live Drawing File

By P. H. White

MANUFACTURING plants suffering from "growing pains" often are confronted with the problems of keeping the drawing file in such condition that any drawing required can be located immediately. The writer recently supervised the renovation of an extensive drawing file covering a period of about fifteen years, and kept half-heartedly during this time. During this period the product of the plant had been redesigned a number of times, some lines dropped, and numerous changes made. In addition to drawings of the manufactured products themselves, the files contained many tool, die, and machine drawings, as well as installation drawings.

It was decided at first to preserve all drawings for three years back, but all drawings of tools and special machines which were still in use were kept regardless of age. Also certain installation drawings which illustrated some special application were given a place in the files.

A card index then was made of all drawings that were to be kept, listings being made of every subject under which each drawing might be classified. The cards then were filed alphabetically, while a numerical index was made in a book. Each card gave the name of the drawing, its number, and its location in the files. It is now planned to weed out the files every two years.



Welded chrome-molybdenum steel tube fuselage frame of the Barling NB-3 monoplane

METALS *in* *Aircraft Construction*

By JOHN F. HARDECKER
Chief Draftsman, Naval Aircraft Factory

Aluminum and magnesium alloys, high-strength and good-welding steels, stainless steel and other corrosion-resisting metals, find numerous aircraft applications

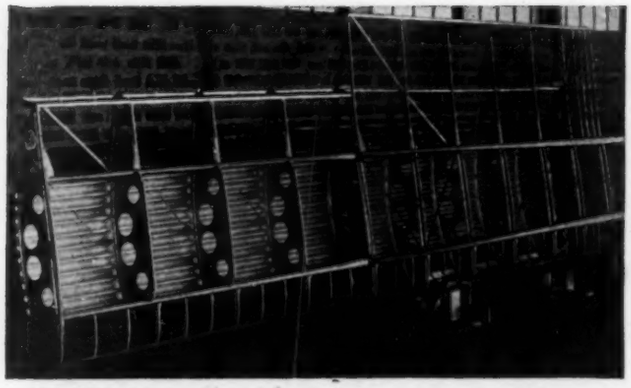
MORE and more, as the airplane industry approaches real quantity production, metal becomes the predominating material of aeronautical fabrication. True mass production can be attained only when machine processes generally take the place of hand work, and metal is essentially the material of maximum machine utility. Even though the costs of experimental and development work run high in the metal field, the airplane manufacturer realizes that, if he wishes to attain the maximum benefits of metal utilization he must do so from the very beginning, for a wood structure cannot be duplicated directly in metal, without losing most of the inherent advantages of metal, and increasing the weight. Only by a proper design in metal from the very beginning, taking advantage of all the physical properties peculiar to metal and attainable through metal fabrication processes, essentially different in the case of wood, can the true weight saving, reliability, and permanence of a metal plane be realized.

While Duralumin, or similar alloys, such as "175," lead all other metals used in aircraft work, there is a wide application of almost all the commercial metals in airplane construction. In fact, the care with which aircraft materials are selected for each specific purpose, assures any metal with outstanding advantages some form of application in the modern airplane.

As larger and larger sizes of aircraft are developed, the utilization of the heavier metals, such as steel and Monel metal becomes more logical and reasonable. For example, in the R100 airship, a ship considerably larger than the Graf Zeppelin, which is now nearing completion in England, stainless steel has been introduced for the first time in considerable quantity in lighter-than-air craft. The structure of R100 is roughly half stainless steel and half Duralumin.

The choice of materials for any given part of an airplane normally is not based upon any outstanding generality, which assures its utilization for all similar purposes, but is based, rather, upon a special study of the particular part in the particular plane or engine, in relation to the design as a whole. Therefore, the metals here mentioned for particular uses are not the only ones so utilized; they are merely outstanding examples of application.

Duralumin is the outstanding metal for wing construction, with riveting used as the means of fabrication. Pressed or stamped Duralumin ribs, having simple sections formed on the brake, and either flat or corrugated Duralumin or cloth covering, are used. Beams are Duralumin or steel tubing, built-up Duralumin stampings, or any of the parts just mentioned, in combination with special extruded Duralumin shapes. The reason for employing Duralumin is that its strength, after heat treatment, is equal to that of mild carbon steel, while it weighs only one-third as much. Its chief disadvantage is that Duralumin welding has not progressed to the stage where it is considered advisable when strength is an important factor. For this reason, the more difficult and expensive riveting has to be employed. Recent developments have introduced ribs made of corrosion-resisting



An all-metal wing structure, used in Barling NB-3, has a box-shaped corrugated Duralumin beam and zigzag struts of welded chrome-molybdenum steel

steel, fabricated by special brazing or welding. The production economy and durability of this type of construction are obvious.

Recent developments also have made possible the heat-treatment of long alloy-steel beams to high tensile strength without appreciable distortion. Fabricated sheet-steel fittings, assembled by welding or brazing, machined steel or Duralumin fittings, and drop-forged steel fittings are used extensively in wooden wing construction, as well as for the more highly stressed joints of metal wings.

For tension bracing, both internal and external, steel wires of S.A.E. 1045 or S.A.E. 1050 steel, in the form of tie rods are employed. These are streamlined in shape for external use and are round or square for internal use. These wires are heat-treated, and all cold work, such as drawing and rolling, is done after heat-treatment. In wood wing construction, Duralumin or aluminum tubing, or bronze cable generally is employed for trailing edges. Each metal used is the result of careful selection and analysis, far too detailed to permit of generalization. In fuselage construction there is a decided trend towards the welded chrome-molybdenum tube frame. Because of its excellent welding properties and strength (90,000 lb. per sq. in. after welding), chrome-molybdenum steel (S.A.E. 4130x) possesses advantages of fabrication, particularly when well-designed jigs are employed. It is a decidedly convenient and economical material for mass production and assembly. Usual practice employs round steel tubes, braced in truss form, with the tube axes intersecting at joints. Four longitudinal members, braced by additional cross tubes or steel wires, establish the rectangular cross section, except in the forward portion of the fuselage, where the cross bracing must be omitted to give an unobstructed interior. Square steel tubing sometimes is used, partly because it facilitates manufacture, and partly because it affords greater protection against crash crushing around passenger cockpits.

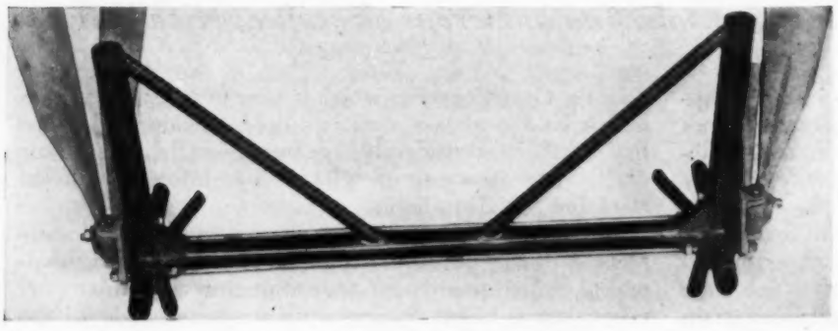
An interesting recent development in fuselage construction has been the use of extruded Duralumin angles and channels, fabricated by riveting. An intimate study of designs involving simple, flat, gusset plates has resulted in an entirely satisfactory and relatively simple structure.

Until recently, practically all fittings of metal aircraft have been of welded steel construction. Now there is an increasing tendency towards forgings and high-strength aluminum alloy castings. These parts usually are developed first by building up a welded fitting, and later by replacing it with a forging or casting. Steel tie-rods, round or square, are used for tension members in fuselage as well as in wing construction. In one instance, at least, an ingenious arrangement of these rods puts certain welded joints in compression instead of tension.

Modern flying boat hull structures are fabricated largely from Duralumin. Sections used include simple angles, channels, Z-bars, and bulb-angles made on the brake from sheet, or by extrusion. Besides the generally accepted advantages of metal construction, metal hulls possess one great advantage over wooden hulls in that the very considerable absorption of water and consequent increase in weight of the wooden hull is avoided. The accepted method of fabrication is by riveting. Machined or forged Duralumin fittings, as well as built-up steel fittings, are employed at critical points.

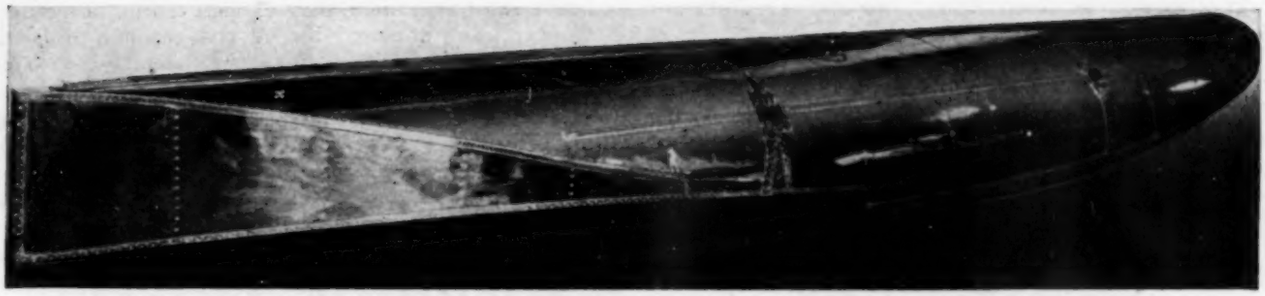
Almost all the standard airplanes now in commercial use have alternative float-type landing gears for operation as seaplanes. The seaplane is gaining rapidly in favor because of the far greater accessibility of water bases to large centers of population, and because of the availability of water in remote regions where the nature of the ground makes landing fields impossible. Prevailing practice centers about Duralumin-covered all-metal floats, built upon a frame of extruded heat-treated Duralumin angle sections, and fastened with heat-treated Duralumin rivets. Alternate practice, less frequently employed, utilizes Duralumin pressings and simple members formed on the brake.

Metal floats have been developed to the point where they are available



Transverse section of Fairchild fuselage. The steel tie-rods place the welds in compression instead of tension

Aerol oleo-pneumatic strut, to replace rubber cord shock-absorbing devices in landing gears on many types of airplanes



Brewster Monel metal float built for Bureau of Aeronautics, U. S. Navy

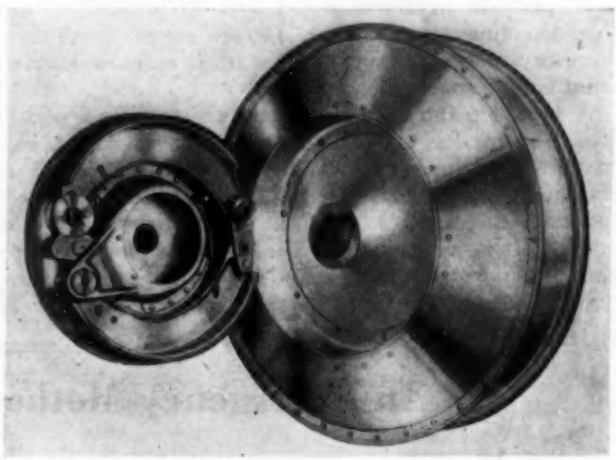
in a set of standard sizes to fit a wide range of commercial planes. An interesting recent development is the construction of floats of Monel metal which, while somewhat heavier, affords greater resistance to salt water corrosion than Duralumin.

Steel stream-lined struts and wire are chosen for most float installations. In certain instances Duralumin struts have been used, but steel is preferred because of its greater corrosion resistance.

Metal amphibians are increasing in popularity because their retractable landing wheels make it possible to land either on water or on a field. Steel predominates in the wheel-retractor mechanism but many other metals are used. While composite construction (metal covering on wood frames) has been used, the tendency is towards all-metal construction.

Wheel-type landing gears present many interesting applications of metals. In addition to the well-known steel wire wheel coming originally from the automobile industry, there is the Duralumin disk wheel with integral brake drum. A recent innovation is the "air-wheel," in which the rubber air cushion is so large that almost no wheel remains, the tire mounting directly on a Duralumin hub. The familiar rubber shock-absorber cord and rubber landing gear disks are rapidly giving way to the metal oleo-pneumatic landing strut which is far more effective in absorbing landing impact shocks. Landing-gear cross braces, axles, struts and other parts generally are made of alloy steel, usually stream-lined in shape. Occasionally Duralumin tubing finds application. Sheet aluminum is used on circular fairings for wire wheels, and, more recently, in streamline shoes which cover almost the entire wheel, greatly reducing air resistance, with consequent increase of plane speed. In general, fittings have been built up of welded steel stampings, although there is a tendency towards aluminum alloy and manganese-bronze castings, or forgings, of various materials, including steel and strong non-ferrous alloys.

Control surfaces, which include the stabilizer, fin, elevators, and rudder, generally grouped as the tail surfaces, and the ailerons, which are attached to the wings, often are built of pressed Duralumin ribs and Duralumin and steel tubing, riveted together. Control surfaces of welded steel tubing also are becoming common. They usually consist of one large-diameter main member with light-gage small-diameter tubes welded to it. Fabric or corrugated Duralumin is the usual covering material.



Bendix brake and disk wheel with integral Duralumin brake-drum and other light alloy parts

Part of fuselage frame made from extruded Duralumin shapes fabricated with round-head Duralumin rivets

Standard structural parts, such as bolts, nuts, washers, shackles, and the like, usually are made either of S.A.E. 2330 nickel-alloy steel or S.A.E. 1025 medium-carbon steel. Turnbuckle barrels are made of naval rolled brass, and thimbles of S.A.E. 1010 mild-carbon steel. Extra-flexible steel cord of seven strands, each strand containing 19 wires, is used in the interior of planes for control leads on the ailerons, elevators and rudder. Brass nails, copper rivets and burrs, brass wood screws, copper purlin nails, and like parts in general use in wood fabrication, are merely commercial grades of the particular metal. The same applies to steel and brass cotter pins.

Lightness in aircraft engines is attained largely by the intelligent selection of materials, which results in the use of an extremely wide range of metals in any given engine. Alloy steels are used, of course, for crankshafts, connecting rods, and other highly stressed parts. Aluminum alloy and other sheet metals are used for parts that need not possess much strength, such as water jackets, crankcases, pumps, and manifolds. Cylinders often are of cast aluminum alloy, but require an iron or steel liner to give the necessary strength and wearing qualities. Magnesium alloys also have possi-

bilities as cylinder liners, being comparatively light and wear-resisting.

Pistons for airplane engines generally are made of magnesium or aluminum alloys such as Magnalite and Lynite. Copper, forming about 8 per cent, is usually the alloying material, although zinc is used to a slight extent, and in some cases nickel is a constituent. Aluminum is advantageous mainly because of its lightness and superior heat conductivity, although the fact that it will not rust is important. It also makes a satisfactory bearing for piston pins, hence no pin bushings need be used. When aluminum is employed for cylinder heads, it becomes necessary to provide steel or bronze valve seats, because aluminum is too soft and malleable to stand up under the constant hammering of a valve. Passages for oil through aluminum castings should be lined with steel tubes, to prevent high-pressure oil from breaking through porous places.

Bohnalite, which is 62 per cent lighter than iron, is a new magnesium-aluminum alloy finding increasing use for aircraft engine crankcases, pistons, cylinder heads, and like parts. A still lighter alloy, Bohnalite X, which is 78 per cent lighter than iron and 36 per cent lighter than aluminum, is used for aircraft engine crankcases, accessory drive housings, air-starter crankcases, and front engine covers.

A typical 600-hp. modern, fluid (water or chemical) cooled engine has six carbon-steel cylinders shrunk into each cast-aluminum cylinder head. Valves are seated on aluminum-bronze seats inserted in the head. The water jacket is cast from high-tensile aluminum alloy. The crankshaft is a single-piece chrome-nickel steel forging and the crankcase is an aluminum-alloy casting. Connecting rods are of forged steel, while pistons are of a heat-treated aluminum alloy of high tensile properties.

Copper tubes are used for oil and gasoline leads on account of their ability to withstand vibration without breakage, although, even here, it is considered good practice, after long use, to remove the lines and re-anneal them before they are put back into place. Aluminum and Duralumin tubing, at one time employed for oil lines, is used no longer, for it did not stand up properly in service. Tube fittings generally are made from brass castings, bar stock, or forgings. Combinations of brass and aluminum have been used to save weight, but in no case should two aluminum parts be threaded together, as the threads freeze.

Tanks generally are of welded aluminum construction, with ample baffles to prevent the too sudden shifting of their contents. Duralumin tanks with riveted construction, using soft aluminum inter-liners at the joints, show considerable promise, but welded Duralumin tanks are still very much in the experimental stage. Terne plate tanks are employed in certain cases.

In aircraft equipment for the accommodation of passengers, and for other useful purposes, the governing considerations are usually not so strictly limited and almost all common metals are used.

According to a statement issued by the Ford Motor Company, neither convenience nor prejudice dictated the adoption of all metal construction in its planes. Metal was selected because it lent itself to manufacturing requirements, operating efficiency, economy, and safety. It was decided upon after it had definitely proved its superiority over other materials in every respect. For these and other reasons already mentioned, there appears to be little doubt that metals will find increasing use in aircraft construction.

An Emergency Method of Thread Calculation

By Peter Hagen
Department of Engineering, Naval Aircraft Factory, Philadelphia

OCCASIONAL difficulties arise in the shop that tend to evade existing principles. One of these recently presented itself in a broken automatic die block that was furnished as a working sample, and from which dimensions were to be calculated for machining a similar, urgently needed block. All was comparatively easy until the mechanic tried to gage the thread system to be used in drilling and tapping the inside-threaded rider-boss upon which the eccentric throw arm rotated.

Both the eccentric arm and the retaining bolt had been removed by the customer, else the threaded portion of the bolt would have sufficed for gaging purposes in arriving at the necessary thread diameters. But without the bolt, and having exhausted every conceivable method to determine the diameters, including trials with various taps, the engineering department was called upon to clarify the situation.

Finding that handbooks were unavailing, and that standard thread systems were not readily applicable to this particular case, it was evident to the draftsman that strategy must be resorted to in order to determine, to some degree of accuracy, the most important factor—the major diameter of the internal threads.

A solution was evolved by obtaining a cylindrical soft pine stick, slightly greater in diameter than the assumed maximum diameter of the threads. The end was tapered slightly for ease of entering, then the stick was screwed into the threaded hole to a depth of about $\frac{1}{4}$ in., the threads forming themselves on the stick under the pressure of turning.

Upon removal of the stick, the threads appeared to be practically perfect. These were "miked" with care, and the reading 0.208 in., estimated to be correct to within a tolerance 0.002 in., used later as a basis for computing the pitch diameter.

The number of threads, derived by use of a thread gage, showed readily that the standard United States form series had been used, thus giving the angle of threads for additional estimating purposes.

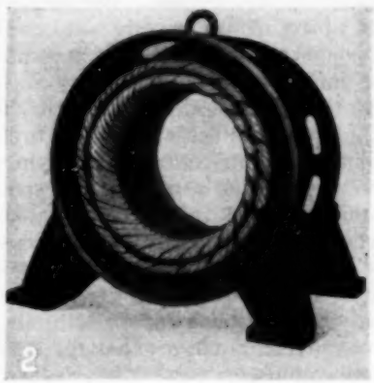
Equipped with a maximum thread diameter and the number of threads per inch, the draftsman proceeded to complete a working sketch for the machinist, resorting now to his handbook on screw thread systems for acquiring additional data.

This method is valuable in emergencies where preparations manufactured for this purpose are not available.

In the construction of the ZMC-2 all-metal Zeppelin Alclad sheet, 0.009 in. in thickness was employed. The sheets were sewed together in a special riveting machine with three rows of small aluminum rivets.

Adjustable-Speed d.c. vs. Multi-Speed a.c. MOTORS

For Machine Tools



By C. E. L. DAPPRICH

General Engineer
Westinghouse Electric & Manufacturing Company

WHAT are the advantages and disadvantages of the various types of a.c. and d.c. motors for individual drive of machine tools? Which type should be chosen for a given set of conditions? Should the drive be direct, or should one or more gear reductions be employed?—These, and many other related questions, confront the machine tool designer in particular, and the purchaser of his product in a more limited way. They cannot be answered categorically. Neither can a brief article answer them fully. But certain facts, which are useful in arriving at a conclusion, are given in following paragraphs.

To avoid misunderstanding, it is necessary to define briefly the various types of motors applicable to machine tool drives: An adjustable-speed motor is one, the speed of which may be adjusted or selected at the will of the operator. At any particular setting it will operate at a practically constant speed irrespective of load fluctuations. A varying-speed motor is one, the speed of which is affected greatly by load fluctuations, its speed increasing with a decrease in load, and vice versa. A constant-speed motor is one, the speed of which cannot be changed and is practically unaffected by the load.

LESS GEARING WITH D.C. MOTORS

An advantage of the d.c. adjustable-speed motor over the constant-speed motor is that it eliminates some of the gearing required to obtain the desired speeds. In some cases it is uneconomical to dispense with all gearing, because this requires a larger and more expensive motor. Hence, as a rule, there are one or more gear reductions between the motor shaft and the working spindles. An exception is found in grinders in which the motor can be mounted on the same shaft or coupled to the working spindle.

Except for such machine tools and appliances as always are run at the same speed, it is convenient if not essential to have motors which can be operated at any one of a number of speeds. The shunt-wound d.c. motor with field control has this characteristic, and, in a limited sense, so also has the multi-speed polyphase induction motor.

Although the same complete control of speed, obtainable on an adjustable-speed d.c. motor, is possible with a special type of a.c. polyphase motor operating from a circuit with a fixed frequency, it requires a machine with a relatively large commutator, because of the large number of commutator bars, and a greatly increased number of brush arms. There are, in addition, other complications if more than the usual 3 to 1 speed range is required. On such a motor the change of speed is obtained by shifting the rocker ring. If the motor is located near the operator, this can be accomplished by a system of levers, but if the motor is located at some distance, an auxiliary motor, usually controlled by a set of push-buttons, must be used to shift the rocker ring, an arrangement which, of course, involves some complications otherwise avoided.

The shunt-wound d.c. motor with a rheostat in the field circuit is far more convenient and reliable. Moreover, the first cost, as well as the maintenance expense, of such a d.c. motor tends to be less than with the equivalent a.c. motor. Altogether, the higher costs incurred by using such a.c. motor are hardly warranted, provided some other less expensive arrangement that will be satisfactory can be found. Motors of this type have been applied to some extent abroad, and also in a rather limited manner in this country. Their installation apparently is encouraged by their theoretical advantages, but, on the other hand, is definitely retarded by the practical con-

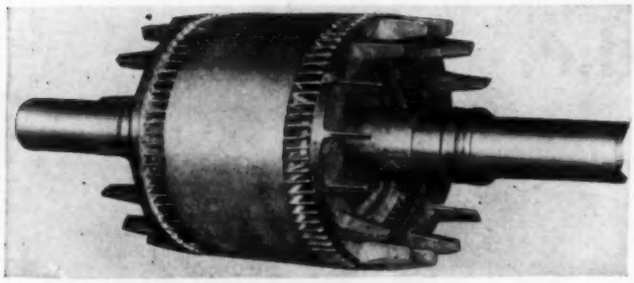


Fig. 3—Rotor used in the frame of the a.c. multi-speed motor shown in Fig. 2

siderations of higher cost and increased operating difficulties.

Slip-ring or wound-rotor induction motors are not adjustable-speed but varying-speed types. Their speed can be reduced by inserting resistance into the secondary circuit but a change of load also varies the speed. As the load decreases the speed rises, and vice versa.

The outstanding operating advantages of the adjustable-speed d.c. motor are the ease with which its speed can be adjusted in finely graduated steps, and its economy. By merely changing the setting of a rheostat, which carries only the relatively small field current of the motor, the speed can be increased in the ratio of 3 or 4 to 1, and, under certain favorable conditions, in even higher ratios. If, in addition to this, the voltage impressed upon the armature is varied suitably, the speed range can be extended in the ratio of 8 to 1, or even 18 to 1. Since the field current is small, as compared to the armature current, its value has practically no effect upon the motor efficiency; that is, it does not make much difference whether the full field current or only a reduced current is flowing in the field coils; the efficiency will be only slightly affected. This is quite different from speed control with armature resistance, in which case the efficiency drops rapidly as the speed is reduced, while this latter method of regulation also has the disadvantage that it gives the motor varying-speed characteristics.

The use of commutating poles, auxiliary poles, or interpoles, as they are variously known, has nothing to do with the matter of adjusting the speed of a d.c. motor by changing the field current, for that can be done with equal facility on motors which do not have commutating poles. The only purpose of such auxiliary poles is to assure good commutation at all speeds. Fig. 1 shows the frame, poles, and coils of a medium size adjustable-speed motor. The yoke ring is of rolled steel welded together.

The standard machine tool ratings for 230-volt and 550-volt d.c. adjustable-speed motors adopted by the National Electrical Manufacturers Association are given in Table I. These ratings are all on a one-hour basis for 50 deg. C. temperature rise, and apply either to open or to semi-inclosed motors. Grinder motors, being more intermittently operated and totally inclosed without ventilation, cannot use these ratings. They usually carry a ½-hour, 55-deg. C. rating instead. The speed ratio on these hardly ever exceeds 2 to 1, but is usually about 1½ to 1.

The tremendous extent and continued rapid growth of two- and three-phase alternating-current distribution for power, has made it imperative for the machine tool and appliance builders to give careful consideration to the kind of current which is available in the customer's plant, and hence, to the type of motor which can be operated from it. In the past, when direct current was practically the only current available, it was customary to design the machine without regard to the motor. Then, if the driving speeds were required to be adjustable to suit the various classes of work, a d.c. adjustable-speed motor was selected and belted or geared to the machine tool. That was, of course, the easiest way for the machine tool designer to proceed, since it did not hamper his layout with the consideration of the best motor speeds. He knew that he could get a motor of almost any desired speed within reason. But since public service power circuits now are mostly a.c., and will soon be all a.c. throughout the country, it appears that this practice can be improved upon for many classes of machine tools. On the other hand, the d.c. adjustable-speed motor offers the most satisfactory solution for certain classes of machine tool application. A maximum-duty grinder is of this type. The widely spaced speeds on the multi-speed squirrel-cage induction motor practically precludes its use where finely graduated speed steps are required.

Planer applications, on account of the additional operating feature of frequent reversal, can be met successfully only by adjustable-speed d.c. motors. If only a.c. service is available, a motor-generator set must be used for such applications.

Since lathes, boring mills, and planer-type milling machines usually include some fixed-ratio gearing between the drive shaft and the working spindle, it is not an exceedingly expensive matter to add selective ratio gearing which will increase the number of speeds available to the point where an a.c. multi-speed motor can be used effectively. This eliminates the need of a motor-generator set for these classes of machines.

Multi-speed induction motors have windings which can be so connected as to give the effect of different numbers

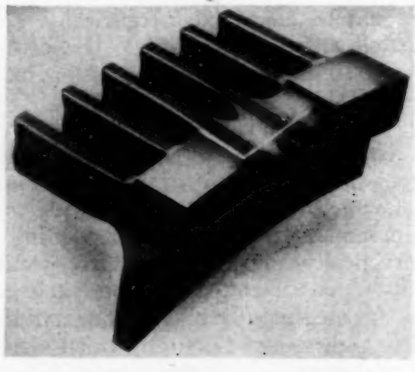
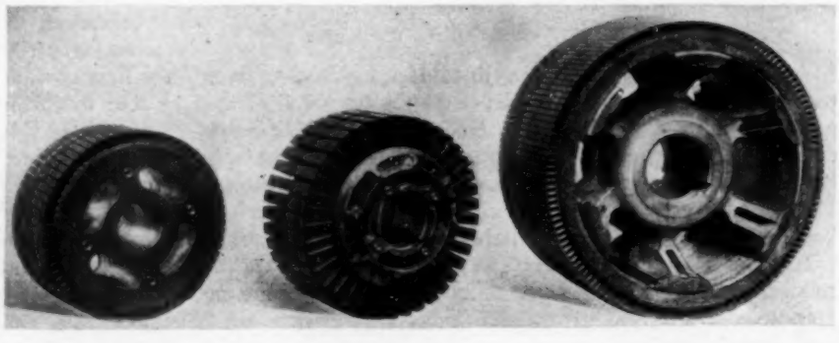


Fig. 4—Detail, showing brazed junction between bars and rings

Fig. 5—Typical rotor cores and an armature core without shafts or windings



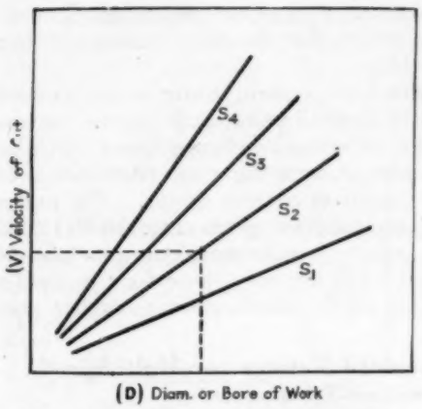


Fig. 6—Graphic method of presenting the speed conditions in a machine tool

of poles. Their no-load, or approximately synchronous, speed in r.p.m. = cycles × 120 ÷ No. of poles. Although the speed of slip-ring induction motors, as well as that of the squirrel-cage type, can be varied, only the latter type has attained a widespread use and is offered in standard ratings by various electric motor manufacturers.

The simplest multi-speed squirrel-cage motor has two speeds. In a 60-cycle motor the no-load speeds may be 600-1,200, 900-1,800, 1,800-3,600, etc. Such motors require only one primary winding, and, assuming either two-phase or three-phase windings, only six terminal leads need be brought out. These are connected in one of two different ways, depending upon whether the high or the low speed is selected. In order, then, to get four speeds instead of two, two independent windings are placed in the same stator slots, and six leads are brought out from each winding, or a total of 12 leads per motor. Fig. 2 shows the stator of a multi-speed motor. Fig. 3 shows the rotor used in the motor, the shaft being designed for sealed-sleeve bearings. The rotor bars and rings are brazed together with a special low-resistance spelter which unites them into a substantial squirrel-cage. In Fig. 4 is illustrated the junction of the brazed bars and rings. In smaller motors a cast aluminum rotor is used. The bars, rings, and ventilating vanes are cast integral, making an equally substantial construction.

Some typical rotor cores and an armature core are shown without shafts or windings in Fig. 5. The smaller cores are riveted together, and the larger core is built up and held together by cast iron endplates keyed to the cast iron spider. These cores are pressed on and keyed to the shafts.

Some of the no-load speeds that can be obtained on a four-speed, 60-cycle motor are given below. The full-load speed in every case is from 4 to 8 per cent lower than the no-load speed.

3,600/1,800/1,200/600 corresponding to 2/4/6/12 poles.

1,800/1,200/900/600 corresponding to 4/6/8/12 poles.

1,200/900/600/450 corresponding to 8/10/12/16 poles.

900/720/450/360 corresponding to 8/10/16/20 poles.

Table II gives the standard multi-speed ratings of motors available for constant torque, that is, horsepower proportional to the speed. The ratings are for 40-deg. C. temperature rise in continuous operation.

The superior speed regulation of the multi-speed motor makes it more desirable than the adjustable-speed motor, particularly on the higher speeds. Where the multi-speed motor at full load slows down about 4 to 8 per cent, the adjustable-speed motor drops off slightly more than this at low speed and about three times this much at high speed. There is also a period of about an hour, immediately after the d.c. motor starts, during which its speed almost imperceptibly creeps up, due to the heating of the field. It is admittedly easy to change the speed of the adjustable-speed motor, but it often is necessary to make such adjustments in speed to offset the effect of load variations and of variations due to heating. On the other hand, the d.c. motor easily can take care of almost any starting condition of the driven machine, whereas it is sometimes quite difficult to get sufficiently high starting torques on the lower speed windings of the multi-speed motor. On most machine tools, however, the question of starting torque is not vital.

To avoid the necessity of converting alternating into direct current for the operation of an adjustable-speed motor, it is possible to use a multi-speed motor with additional sets of change gears. The additional gears are needed to get intermediate speeds not obtainable electrically. One point to bear in mind is that, even if an adjustable-speed d.c. motor were used, a fixed gear reduction and at least several selective gear reductions as well, still would be required in most cases in order to keep the size and cost of the motor within reasonable limits. The reason for the selective gear reductions is that the speed range required on the working spindle usually is far too great to be obtained by the use of even a very special or high-range adjustable-speed motor. To adapt a motor with a 4 to 1 range to a lathe with spindle speeds ranging from 12 to 600 r.p.m. requires that a ratio of 12½ to 1 be obtained by means of selective gears. On special machines, which do not require more than a 5 to 1 range of speed, a d.c. motor with direct drive can be used, providing that the motor speed involved is not too low. A graphical way of presenting the speed conditions in a machine tool is shown in the diagram, Fig. 6, in which the bore or diameter of work is D. The location of each speed line, S_1, S_2, etc., can be calculated from the formula: $V = \pi D S \div 60$, where V = velocity of cut in feet per second, and S = speed in r.p.m. From such a diagram

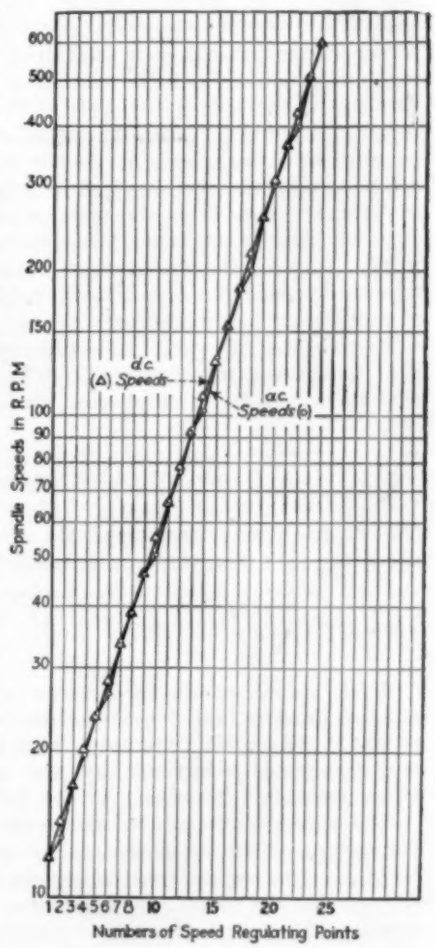


Fig. 7—Spindle speeds obtainable with equally-spaced regulating points on the controller with a.c. and d.c. motors

Table I—Adjustable Speed 230- to 550-Volt d.c. Open or Semi-Enclosed Frame Motor Ratings

Hp.	Speed Ratio 3:1 Min. Speed	Speed Ratio 3:1 Max. Speed	Speed Ratio 4:1 Min. Speed	Speed Ratio 4:1 Max. Speed
½	....	....	600	2400
¾	....	....	600	2400
1	....	....	500	2000
1½	....	....	500	2000
2	700	2100	500	2000
3	650	1950	500	2000
5	650	1950	450	1800
7½	650	1800	450	1800
10	600	1800	300	1200
			400	1600
15	550	1650	300	1200
			400	1600
20	500	1500	300	1200
			400	1600
25	500	1500	300	1200
			400	1600
35	500	1500	300	1200
50	400	1200	300	1200

the cutting speed at a certain diameter, and with a certain spindle speed, is seen readily. Or with a desired cutting speed, and a certain diameter of work, the correct spindle speed may be selected from the diagram.

Another graphical way of presenting the speed relations in a machine tool is by a diagram such as that in Fig. 7, laid out on cross-section paper having equally spaced divisions for abscissa and logarithmic divisions for ordinates; the abscissa indicating the equally spaced regulating points, and the ordinates indicating spindle speeds. If the speeds for each of the regulating points form a geometrical series, they will fall on a straight line passing through the origin. If the multiplier is not the same in each case, the lines will be jagged. Undoubtedly a slight deviation from the true geometrical progression is permissible in practice. The following example gives a clear idea of the comparative results when using an adjustable-speed d.c. motor with gears and when using a multi-speed a.c. motor with gears.

In the case of a d.c. adjustable-speed motor having gear reductions, to obtain 24 spindle speeds from 12 to 600 r.p.m., L, the multiplier in the geometric ratio $= \sqrt[N-1]{S_m \div S_1}$, where S_m = maximum spindle speed = 600 r.p.m. (approximately), S_1 = minimum spindle speed = 12 r.p.m. and N = number of steps = 24.

Thus $L = \sqrt[23]{\frac{600}{12}} = 1.1855$.

At the lowest spindle speed and motor speed the reduction obtained is that due to the gearing alone, hence, it is $600 \div 12 = 50$. This total ratio is disposed in several changeable reductions, and also in a fixed reduction to complete the train, thus: $3.90 \times 3.90 \times 3.28 = 50$.

The speed range of the motor by field control must suffice to take the spindle speed from its minimum of 600 to just below the step, where the first reduction can omitted and the motor speed be reduced to the minimum again. This range of motor speeds is numerically obtained by dividing the ratio of the change gear reductions by the multiplier: $3.9 \div 1.1855 = 3.28$. Hence, a motor with a range of approximately 3½ to 1 will be satisfactory in this case. The motor speeds and the corresponding spindle speeds for the entire range are then as shown in Table III.

Now, if an equivalent system, using a multi-speed induction motor of 4/6/8/12 poles on 60 cycles, be laid out, two more sets of selective change gears must be added in order to approximate the geometrical series of speeds used with the direct-current motor. The motor speeds with the pole numbers given are: 1800/1,200/900/600. These are the synchronous, or approximate no-load speeds, and there are only these four particular motor speeds instead of the much greater number used

Table II—Standard Ratings for Multi-Speed, Constant-Torque Motors

No. of poles	4	6	8	12
F. L. r.p.m.	1725	1140	850	580
Rating in hp	2	1.33	1.00	.66
	3	2.00	2.25	1.50
	5	3.33	2.50	1.66
	7.5	5.00	3.75	2.50
	10	6.66	5.00	3.33
	15	10.00	7.50	5.00
	20	13.33	10.00	6.66
	25	16.66	12.50	8.33
	30	20.00	15.00	10.00

with the d.c. motor. Table IV shows the spindle speeds obtained with this arrangement.

The two preceding tabulations, plotted for comparison in Fig. 7, show that, on this application, a multi-speed a.c. motor can be used to advantage in place of an adjustable-speed d.c. motor. The addition of two more sets of selective change gears makes possible the use of a.c. power without its having to be transformed; hence, no motor-generator set is required.

Although the cost of the multi-speed motor and its control is somewhat higher than that of the corresponding adjustable-speed d.c. motor and its control, if the cost of a motor-generator is added to that of the other d.c. equipment, the total cost is greatly in favor of the

Table III—Motor Speeds Corresponding to Various Spindle Speeds with d.c. Adjustable-Speed Motor

Speed Regulating Point No.	Motor Speed	Gear Reduction No. 1	Gear Reduction No. 2	Gear Reduction No. 3	Spindle Speed
1	600	3.28	3.9	3.9	12
2	710	3.28	3.9	3.9	14.2
3	845	3.28	3.9	3.9	16.9
4	1000	3.28	3.9	3.9	20.0
5	1185	3.28	3.9	3.9	23.7
6	1400	3.28	3.9	3.9	28.0
7	1665	3.28	3.9	3.9	33.3
8	1970	3.28	3.9	3.9	39.4
9	600	3.28	3.9	1.00	46.9
10	710	3.28	3.9	1.00	55.4
11	845	3.28	3.9	1.00	65.8
12	1000	3.28	3.9	1.00	78.0
13	1185	3.28	3.9	1.00	92.5
14	1400	3.28	3.9	1.00	109.5
15	1665	3.28	3.9	1.00	130.0
16	1970	3.28	3.9	1.00	154.0
17	600	3.28	1.00	1.00	183
18	710	3.28	1.00	1.00	216
19	845	3.28	1.00	1.00	257
20	1000	3.28	1.00	1.00	304
21	1185	3.28	1.00	1.00	363
22	1400	3.28	1.00	1.00	427
23	1665	3.28	1.00	1.00	508
24	1970	3.28	1.00	1.00	600

a.c. arrangement, even considering the cost of the extra gearing required. This refers to one machine tool unit only. With an increase in the number of units, the cost difference, in favor of the multi-speed motor, becomes less and less. But, whether this difference is large or small, there always is the operating advantage of using a.c. power without converting it. In the average case

Table IV—Motor Speeds Corresponding to Various Spindle Speeds with Multi-Speed Induction Motor

Speed Regulating Point No.	Motor Speed	Gear Reduction No. 1	No. 2	No. 3	No. 4	No. 5	Spindle Speed
1	600	3.280	....	....	3.90	3.90	12
2	600	.....	3.00	....	3.90	3.90	13.2
3	900	.....	....	3.90	3.90	3.90	17.0
4	900	.....	3.00	....	3.90	3.90	19.7
5	1200	3.280	....	....	3.90	3.90	24.0
6	1200	.....	3.00	....	3.90	3.90	26.4
7	1800	.....	....	3.50	3.90	3.90	34.0
8	1800	.....	3.00	....	3.90	3.90	39.4
9	600	3.280	....	....	3.90	1.00	46.9
10	600	.....	3.00	....	3.90	1.00	51.3
11	900	.....	....	3.50	3.90	1.00	66.0
12	900	.....	3.00	....	3.90	1.00	77.0
13	1200	3.280	....	....	3.90	1.00	93.8
14	1200	.....	3.00	....	3.90	1.00	102.3
15	1800	.....	....	3.50	3.90	1.00	132
16	1800	.....	3.00	....	3.90	1.00	154
17	600	3.290	....	....	1.00	1.00	183
18	600	.....	3.00	....	1.00	1.00	200
19	900	.....	....	3.50	1.00	1.00	257
20	900	.....	3.00	....	1.00	1.00	300
21	1200	3.280	....	....	1.00	1.00	366
22	1200	.....	3.00	....	1.00	1.00	400
23	1800	.....	....	3.50	1.00	1.00	514
24	1800	.....	3.00	....	1.00	1.00	600

the power bill with a.c. equipment is only 60 or 70 per cent of that with d.c. equipment. This, however, is an advantage for the purchaser rather than for the builder of the machine tool or appliance.

With the 60-cycle circuits available in almost every industrial center, the available a.c. motor speeds are approximately 3,450; 1,740; 1,160; 860; 690, etc., r.p.m. The 3,450 speed, and speeds of 690 and below, could be eliminated. Stocks of motors with the speeds of 1,740; 1,160; and 860 r.p.m. generally are available in all industrial centers. Instead of setting the speeds of the drive shafts of machine tools at some odd value, it would be of great advantage to have these speeds coincide with "standard" 60-cycle a.c. motor speeds. Such motors then could be coupled without change. Direct-current motors of the constant-speed type usually are offered in these same speeds. Standardization on these speeds would require only that machine tool builders make a slight change, say in gearing, to permit coupling the motor directly to the drive shaft of the tool.

THE glass-topped desk is responsible for many losses in business, according to Dr. E. E. Free, of the New York University, who recently lectured on glare and eyestrain before a group of engineers. The glass top reflects bright points of light into the eye while papers, less brightly lighted, are being examined. The eye tries to adjust itself to both conditions, the pupil alternately expands and contracts, and the result is eye strain, which causes the worker to make mistakes.

· BOOK · REVIEWS ·

THE CREEP OF STEEL AT HIGH TEMPERATURES. *By F. H. Norton. Ninety pages, 6x9 in. Cloth board covers. Published by McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York, N. Y. Price $3.*

ENGINEERS and metallurgists who have to deal with the practical application of steel for use in boilers and other high-temperature apparatus, or with the specifications for such steel, will find much useful information in this book. It gives the results of a long series of tests made by the author, who is Babcock & Wilcox Research Fellow at the Massachusetts Institute of Technology.

With the object of providing data on the safe stresses for various steels at high temperature, the author outlines the problems faced in making the tests, describes the apparatus employed, gives in full the results secured, and discusses and compares them with data obtained by other investigators. The creep results of seventeen types of steel at temperatures above 1,000 deg. F. are given.

*

HANDBOOK OF FORMULAS AND TABLES FOR ENGINEERS. *By Clarence A. Pierce, Walter B. Carver, and Charles E. O'Rourke. 228 pages, 4¼x7 in. Flexible covers. Published by the McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York, N. Y. Price $2.50.*

STUDENTS of engineering, as well as graduate engineers, will find this, the third edition of a book written by professors of engineering and mathematics at Cornell University, a useful and ready reference volume. It contains formulas and tables segregated into the following sections: Algebra; geometry, plane, solid, and analytical; trigonometry; calculus; measurement; physical and chemical properties of substances; mechanics; columns, beams and jointed frames; structural data; concrete and other materials; standard gages and fastenings; steam tables and charts; and various mathematical tables.

In the new edition, there is, in addition to mechanical engineering data, similar data useful to civil engineers. The section on mechanics has been divided into statics, dynamics, hydraulics, and other related subjects. The section on strength of materials has been amplified, and that treating of standards revised and brought up to date. Numerous line cuts and charts are employed.

*

1929 SUPPLEMENT TO BOOK OF A.S.T.M. STANDARDS. This paper-bound book contains two hundred ninety-three 6x9-in. pages, and includes 19 revised and 32 newly adopted standards approved by the Society. Among the standards are those covering high-text cast iron, gray iron, naval brass, cartridge brass, free-cutting brass, and various non-metallic materials. The recommended practice for the radiographic testing of metal castings is also included. The price of the book is $1,50, and it is obtainable directly from the American Society for Testing Materials, 1315 Spruce St., Philadelphia.

Safety Devices for Machinery

By LUTHER D. BURLINGAME

Industrial Superintendent, Brown & Sharpe Manufacturing Company

THE fact that operators who have never before seen the inside of a machine shop are put to work on machines, and that because of modern equipment, employees with lower mentality as well as of less experience are often used, makes the need of "fool-proof guarding" and instruction in safe methods of work more essential if accidents are to be avoided. Training workmen to become "safety-minded" by instruction, by giving them responsibility on safety committees, and by the safety leadership of foremen and management are factors in creating safety, whether in the operation of machine tools or in the many other activities of the factory.

Also important is the matter of clothing, avoiding loose sleeves or long flowing neckties. A loose rag on the finger may be, indeed often has been, the cause of a serious accident, resulting even in the loss of a finger or a hand. One case comes to mind where ravelings from such a rag wound around a revolving drill, drawing in the finger and mangling it to such an extent that amputation was necessary.

PROPER DESIGN OF WRENCHES IS NECESSARY

When handling work where sharp or rough edges are liable to cut the hands, it is sometimes advisable to wear gloves; but generally speaking, the use of gloves around a machine adds a hazard which more than offsets any advantage gained. It is found that an unexpectedly large number of accidents, some being rather serious in nature, result from slipping wrenches. This is often due to the nibs of the wrench being spread so that it does not fit properly. The remedy is frequent inspection and repair of wrenches.

The tendency, for old employees to be conservative and to resist steps taken for their own good is illustrated not only in the use of goggles but also when the use of safety dogs is required. Such workmen will often hunt up old-style dogs with projecting set screws, perhaps secreted for the purpose, instead of using the modern lathe dog with a safety screw. To eliminate entirely from the shop the old and more dangerous type of dog is a way to overcome this tendency.

Another aid to safety is in guarding the cutting point, which has already been named as the point of greatest danger and that most difficult to guard. In woodworking machinery, a greater amount of study has been given to such guarding, and perhaps for that reason, more satisfactory results have followed. Cannot equal study give like results for machine tools? The flying chips from lathe work, the hazard of revolving cutters and drills, the danger from punch presses and shears, and that from grinding wheels will illustrate. At a machine-tool factory with over 6,000 employees, while less than one-fourth of the cost of compensation for accidents was for cases involving machinery, more than three-fourths of the cost which did come in this classification was for accidents occurring at the point of cutting.

A lathe chip guard with a glass opening, so that the work may be safely observed, is widely used, but it has limitations for many kinds of work, in fact to a point where its universal adoption cannot be recommended at present. The same can be said about milling-cutter guards. Many designs have been brought out. Some of these are satisfactory for use on certain jobs; but so far as known, no guard at all applicable universally for this purpose has as yet been devised. The simple expedient of providing a brush to wipe away the chips so that the conditions of cutting can be seen, and strict rules that the fingers shall not be used for this purpose, eliminates one of the greatest hazards in milling machines. Another expedient used to advantage is having a stream of coolant under pressure so that with a hand-operated valve a stream of sufficient force can be thrown against the cutter to clear away the chips. These expedients are, however, palliatives, not cures.

Guarding grinding wheels is quite general, but a hazard exists for internal grinding, in which case it does not seem practicable to provide a guard which can remain in place. The particular hazard here is that when the wheel is run back out of the work and a gage is used for testing the hole there is danger of its releasing suddenly and the hand being cut against the revolving wheel. There are designs of guards to protect against this danger by the guard being swung automatically into place in front of the grinding wheel when the latter is withdrawn from the work, thus protecting the workman in case his hand slips.

Punch presses, among the most dangerous of machines, have had many devices to prevent operation when the hand is in the danger zone. Scores of patents have been taken out for such devices. More confidence might be placed in their use if it were not found so frequently that workmen put them out of commission and that there is no check-up to prevent. If a punch press is equipped so that both hands are required to operate it, how often is one of the handles wired up so that the press can be operated by one hand only, leaving the other free to be mutilated when there is an inadvertent slip? Great as is the ingenuity evidenced in the designing of guards, still greater ingenuity is sometimes displayed by the workman in evading their use!

CORRECTLY DESIGNED GUARDS LESSEN DANGER

The provision of chutes, wiping sticks, tweezers, and similar means of protection for punch-press operators, while adequate safeguards if used, mean continued supervision on the part of the foreman and safety inspector or their use will degenerate into unsafe practices. If tweezers are used, the accidents can at most be to the fingers of the tweezers and not to those of the workman. When guards on any type of machine are left off by workmen, it is well to investigate as to the possibility of providing guards which do not need to be removed, or at least can be swung out of the way and readily returned to position. A conference with foreman and workman will often lead them to take more interest in using the guards successfully, especially if some of their suggestions are adopted.

Abstract of a paper presented at the annual Safety Congress, Chicago, Sept. 30 to Oct. 4.

MOLDED PRODUCTS That Replace Metals

By H. D. RANDALL
Industrial Department, General Electric Company

Knowledge of the properties of molding materials, and careful attention to design principles make possible the development of products that possess definite advantages, and that can be manufactured at low cost

THE first question facing the designer who wishes to make use of molded plastic products is that of the properties which must be possessed by the part he intends to manufacture. Certain factors were discussed in a previous article appearing in the *American Machinist,* Vol. 71, page 251. The kind of material the designer must choose depends on the properties he desires to incorporate. Not all the desirable characteristics may be possessed by any one type of molded compound, and hence those properties most necessary for the product should be first listed, in order of importance, with the non-vital group appended. Then the most suitable type of molded plastic can be chosen. For industrial purposes, the synthetic resin compounds are now probably of the greatest importance, casein plastics being limited to the ornamental field, rubber and shellac to special purposes, asphaltic compounds to cheaper products, and cold-molded mineral-filler plastics to heat-resisting applications.

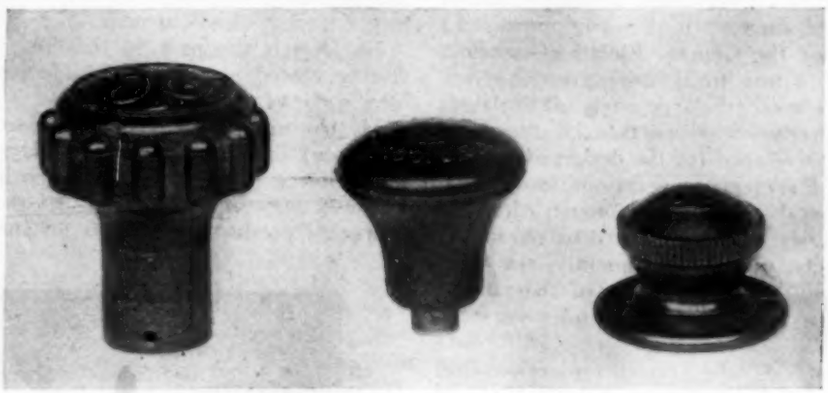


Fig. 10—Handles and knobs are conveniently molded from plastic materials. Those illustrated are, respectively, a handle for an ammeter and reversing switch, a handle for a pull-button control switch, and a switch knob

Service demands for mechanical strength, insulation value, heat resistance and similar requirements, should be investigated, and the parts then proportioned to meet them, according to basic values for the various compounds, about which the manufacturer of the compounds can inform the user. These values have been closely determined from standard tests, and, for uniformly satisfactory results, products must be designed to come wtihin these limits. It is not sufficient to stop here, however. Prospective users are enabled to save a great deal of time and trouble by consulting the engineering department of the concern selected to do their molding, if an outside firm does the work, to straighten out difficulties encountered because of the design of a part, before this design becomes "frozen." This precaution is necessary because most designing engineers do not yet possess the same thorough understanding of molded plastics and their characteristics as they have of the better-known materials, such as cast-iron, wrought-iron, steel, brass, fiber, wood, and others.

Molded plastics differ considerably from die castings, foundry castings, drop forgings, and other products produced from metals by heat or pressure processes, and the design worked up for any particular case may be very difficult and expensive to produce, or may not meet the eventual requirements as to strength values and other factors. Modifications which are easily made may reduce mold complications, cut mold expense, lower production costs, and increase the strength and service properties of the product. Important considerations in design are explained in some manufacturers' catalogs and in a few technical publications and pamphlets, but for unusual or intricate designs it is best to consult with the producer before the details are finally fixed for manufacture.

Extensive tests of initial pieces should also be made to overcome construction problems and to avoid misapplications of the part to the required use. After all the troubles have been corrected, the part may be placed in production.

In connection with the placing of orders with makers of molded products, the fact should be borne in mind that molding concerns endeavor to lay out their mold and press equipment for maximum efficiency. The size of the mold selected and provided is usually proportionate to the initially-stated requirements. Where the volume of output desired is high, multiple-cavity molds can usually be provided. Radio tube bases, for instance, are made in this manner, the larger sizes being produced in molds with 48 cavities, and the smaller sizes in molds with 77 cavities. Molds for smaller parts, such as tooth paste caps, may contain as many as 100 cavities. Preformed disks, tablets or spheres, made in special machines

The conclusion of the article.

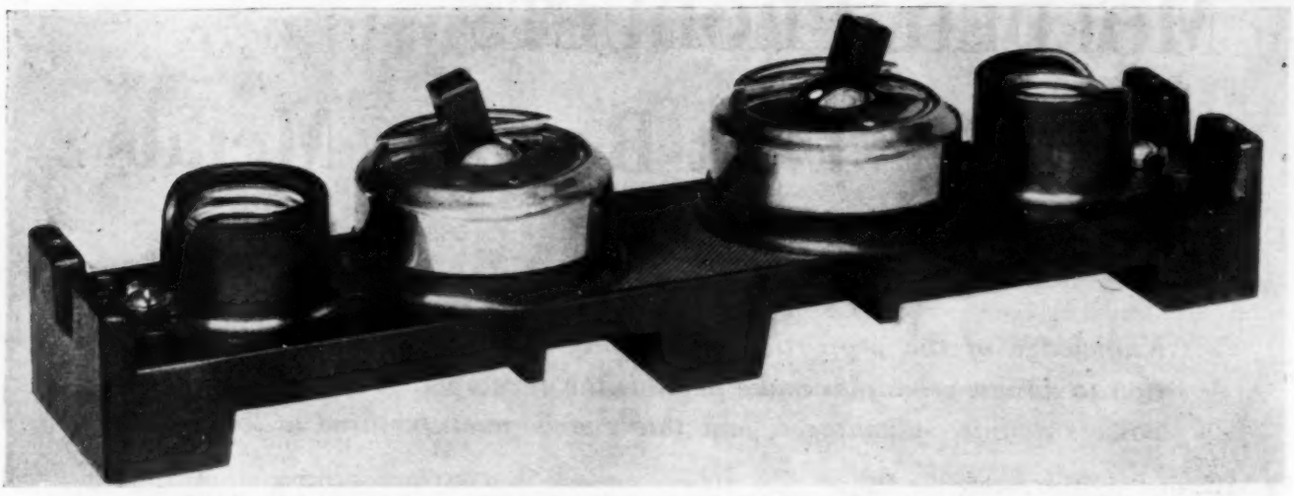


Fig. 11—Panel-board switch assemblies are built up on molded plastic bases formed in one operation

operating at a high rate of production, are employed for molds of the multicavity type. Some products, however, can be made only in single cavity molds. The molds for highly-ornamental products, such as handles for electric percolators, are sometimes hand-carved.

Orders for parts from a given mold should be placed commensurate with the capacity of the equipment. In the molding division of the General Electric Company, presses ranging from 18 tons to 315 tons are employed. The larger presses are used for large parts, or for multiple-cavity molds to produce small parts.

Set rules cannot be developed for the design of molded parts, since the user's preference pertaining to angles, tapers, radii, or general configuration must often be modified to suit the design of mold favored by the maker of the molded products, or, more frequently, the mold he is compelled to use, due to the shape of the part in question. However, a few general principles must be kept in mind:

1. Allow ample draft, or taper, on all projections and depressions on the product. A taper of $\frac{1}{64}$ in. to the inch is enough for hot-molded products. For cold-molded plastics the taper should be $\frac{1}{16}$ in. to the inch. It is seldom necessary to use more.

2. Provide good fillets and round off edges and corners wherever possible.

3. Leave a minimum of $\frac{1}{8}$ in. of material between a hole and the edge of a part, or a projection on it, especially in cold-molded products. If a square hole is left in a round piece, have the corners well inside of the outer wall of the piece.

4. Avoid small holes that necessitate thin pins in the mold, and horizontal holes requiring unsupported pins in the mold. Such pins are apt to bend or break, and thus hamper production.

5. When a row of holes is to be left, see that there is no weakness of material along the center line, or change the shape of the holes from round to rectangular, if this will leave more material.

6. Avoid thin walls or gibs in the product.

7. Where beveled edges are required, see that the design does not call for thin, sharp projections in the mold, which wear off or break readily, thus increasing mold maintenance and interfering with production and the appearance of the part.

8. Use straight knurling instead of the diamond type, so that multiple-part molds can be avoided. Diamond knurled parts cannot be extracted from a plain mold. Eliminate sharp edges on the points of the knurl to simplify machine operations in the mold and strengthen the molded part against chipping off when it is being extracted.

9. Make grooves and threads coarse rather than fine, to get strong, clean-cut edges.

10. Design the part so that required inserts can be readily placed in the mold. Horizontal inserts should have some vertical support.

11. Do not allow inserts or pins to extend from top to bottom of the mold, nor from side to side in a multiple mold closing in at the sides. Such inserts may be oversize and prevent tight closing of the mold, thus giving a spongy product as well as an inaccurate one.

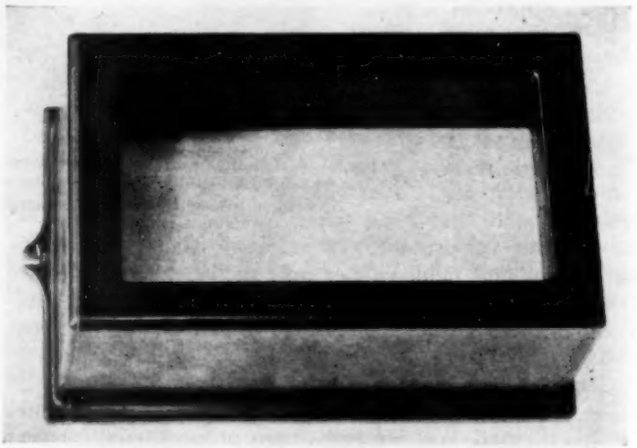


Fig. 12—Boxes, cases, and parts such as the above base for a relay are produced accurate in size and smooth in finish, from molded compounds

Although molding operations permit of producing large quantities of parts quickly and cheaply, with comparatively little variation in dimensions, there are unavoidable deviations which should be anticipated by users of molded plastic products. Some of these variations arise from the desirability of securing economy in mold construction, mold replacement, inspection and assembly. Others are introduced by the customary toolroom tolerances in molded construction, hardening of finished molds, gradual wear of molds in use, and shrinkage and differential strains in intricate designs, leading to slight warpage.

Designers should allow as broad dimensional tolerances

as possible, since manufacture within close tolerances obviously requires greater care, both in mold making and in the production and inspection of the molded parts, resulting in substantially higher cost for mold construction and replacement, as well as higher costs of parts. Dependent upon the design and location of particular dimensions, the maker of molded products, in order to meet close tolerances, may have to resort to machining, shrinking, or other emergency means, and under certain

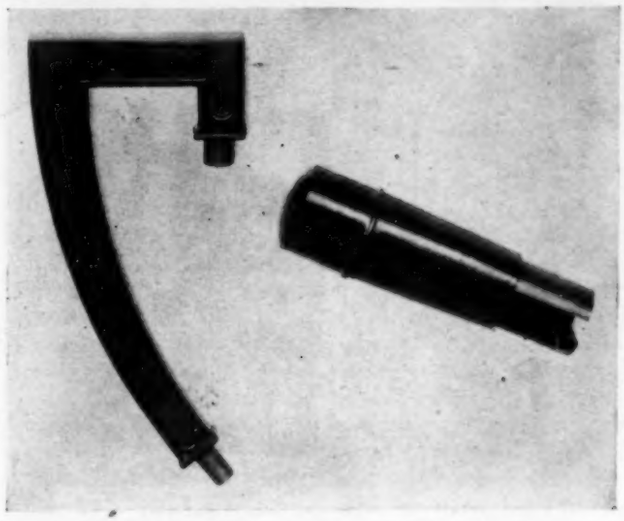


Fig. 13—This percolator handle and the handle for an elevator-car switch are representative industrial molded plastic products

conditions may find it impossible to stay within the narrow limits. If machining has to be done, it removes surface resin films, and may give only temporary accuracy, while sacrificing mechanical or dielectric strength.

To assure satisfactory results a model of the desired molded product, as well as a drawing, should be developed. The model may bring to light difficulties that the drawing does not reveal, and also, it points out where tolerances must be close and where they can be liberal. Draft in the mold is important, to allow for convenient extraction of the piece, and the proportions can be determined from the model.

In calculating the economies of manufacturing parts from molded plastics instead of metals, or porcelain, quantity production becomes a factor. Molds are expensive and a volume of products must be turned out sufficient to offset this investment. The cost of owning and operating lathes, drill presses, screw machines and automatics for metal products must be set off against similar costs for hydraulic presses for molded plastics. Motor-drive or belt-drive, lubrication of operating parts, and coolant for work on machines must be compared with the hydraulic power and steam-heat required on molding presses.

One of the chief advantages in the use of molded plastic products is the ability to reduce an otherwise complicated design and costly manufacturing process to a simple and low-cost proposition. The time element in production is also considerably cut. Another important advantage is the ability to manufacture parts that otherwise could not be produced. This facility, in turn, has made possible the design and manufacture of equipment that it was not possible previously to develop. In fact, the reduction in size of control equipment, resulting from the use of molded plastic parts, has in some cases made it possible to mount this equipment directly on machines, which previously could not be done.

Specific examples of parts produced far more readily and cheaply by replacing metals and insulation with molded plastic materials are given in the accompanying illustrations. The General Electric Company produces more than 5,000,000 molded parts a year for its industrial controller department alone.

Fig. 14—Intricate designs are produced by means of hand-carved molds, in many of the percolator handles now made for the Edison Electric Appliance Company

In the upper left-hand corner of Fig. 16 the two straight bars are molded shafts for magnetic switches. These were formerly made from steel bars. After the ends were turned the bars were wrapped with several layers of varnished paper insulation. Clamps to hold the contact arms were then bolted around this insulation. These clamps were stamped in dies. By substituting molded plastic shafts, the manufacturing procedure was reduced to a low-cost molding process which gave a finished, insulated product in one operation. The pivot ends and holes are formed in the mold, and bolts inserted through

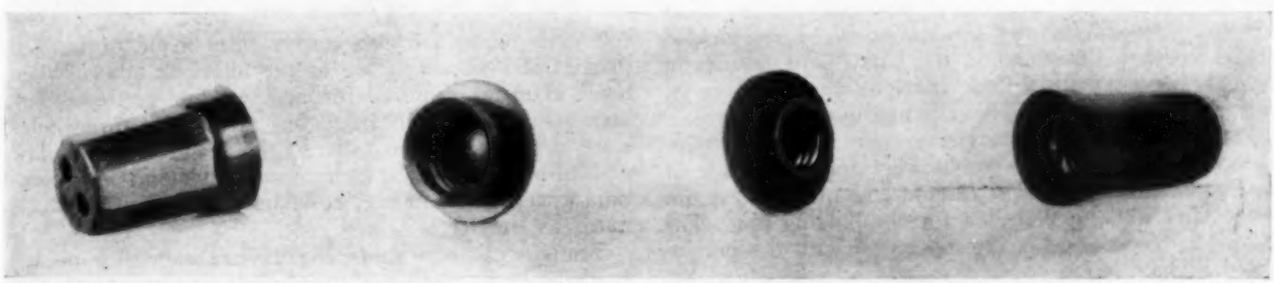


Fig. 15—Sockets for Christmas tree lights, tooth-paste tube caps, and similar caps are made in large quantities in multiple-cavity molds

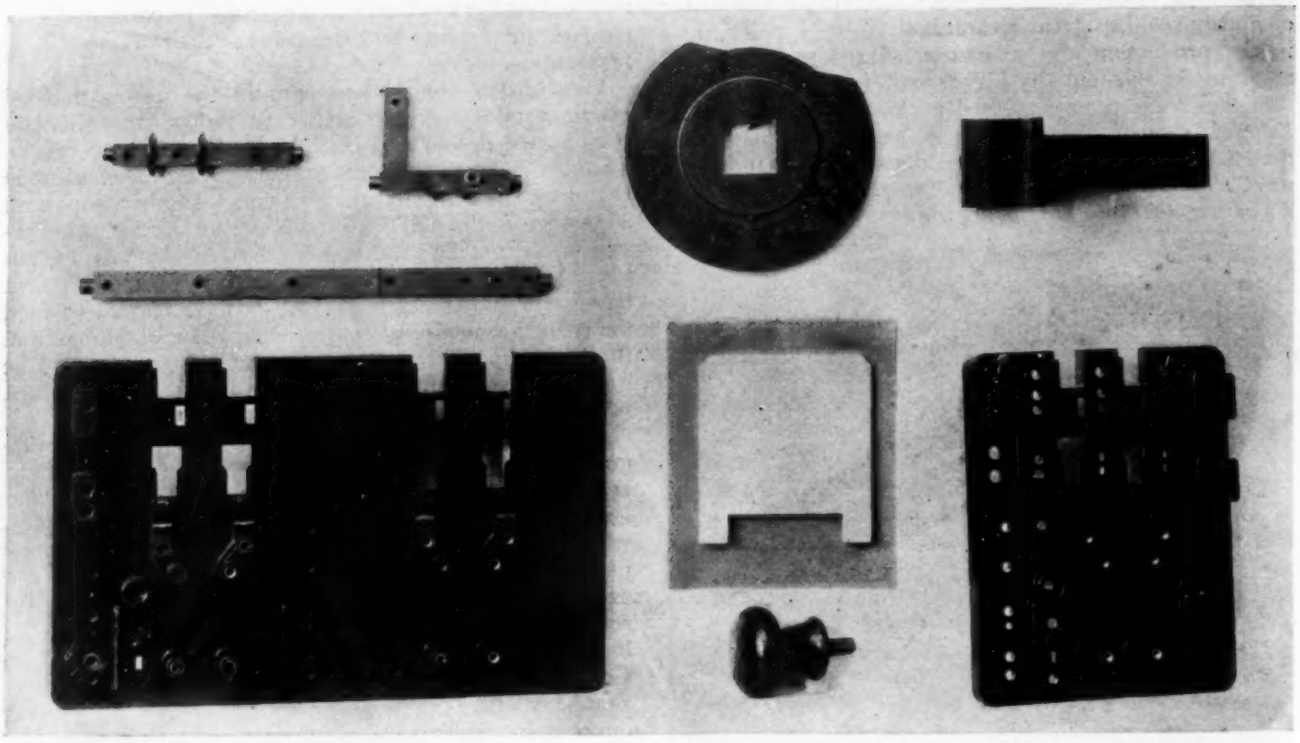


Fig. 16—Products made from molded compounds possess characteristics not obtainable with any other material. The advantages secured by the substitution of such compounds to replace metals, in the parts illustrated above, are described in the text of the article

the holes retain the contact arms on the shafts. The shafts have been shortened because of the higher insulation factor obtained by the construction. The small lugs on the shorter shaft are "creepage" lugs, that is, they obstruct the path through which an arc might otherwise jump.

The other shaft in the upper left-hand corner has its contact arm molded integral with it. The metallic contact is bolted through the hole at the end of the arm.

The limit-switch cam shown in the upper center was previously made from fiber, or insulated metal. The practice now is to mold it from plastic materials.

In the upper right-hand corner a contact support is pictured. This device is approximately 6 in. long overall, 2 in. wide, and 2 in. high. The hollow portion of the broad section must be held to finished dimensions, and likewise a hole leading horizontally into this hollow from the left hand end, one to the right of, and at right angles to, the hexagonal recess shown, and the small hole at the right end, must all be located and dimensioned within close tolerances.

The white object in the center of the illustration is a molded barrier, installed in electrical equipment to prevent arcing. These barriers are now cold-molded from asbestos, lime-silicate and similar bases. Lugs molded integral with the base retain the barriers in cavities in the panels. Previously these barriers were built up of slate or marble, and were heavier and more expensive.

The knob below the barrier is part of a controller oil-switch handle. These knobs were formerly made of wood, were turned, had a ferrule and metal sleeve inserted, and were then drilled for the holding pin. The molded knob is made in one operation with the pin inserted. The cost has been cut to half, and the life of the knobs has been extended indefinitely, whereas the wood knobs failed through checking.

The two large pieces at the left and right in the lower row are magnetic switch panels. Formerly this type of product was built up laboriously and expensively by mounting wood or fiber insulation on a slate back. With molded plastic construction the entire panel is formed and finished in the mold. All surfaces, lugs, grooves, recesses, holes and inserts are accurately located within finished tolerance dimensions and the panel as it comes from the mold is ready for the assembly of the operating mechanism. Far more complicated panels can be constructed within closely limited tolerances, than were possible under building-up methods.

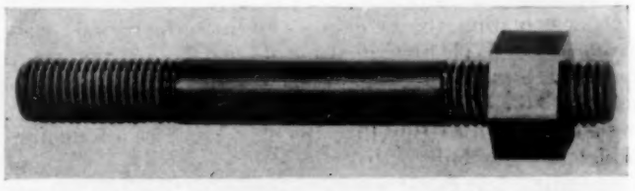


Fig. 17—Transformer studs and nuts possessing both high strength and high insulating value are formed from a molded compound containing a textile filler. It is necessary only to clean the threads at the mold joints by means of special threading and tapping tools

Switch boxes are also conveniently made of molded plastics at low cost. One of the interlock boxes, when made of metal, required forming, welding and considerable insulating. A bearing was riveted in, three holes were drilled, and two others drilled and tapped. The molded plastic product, turned out complete in one operation, except for tapping, costs less than one-twelfth as much as the metal box.

Transformer core studs, Fig. 17, are made of a molded synthetic-resin compound reinforced by cut-up canvass. A two-piece mold is used, and the flash is removed by running a die over the threads to clean them up.

IDEAS FROM PRACTICAL MEN

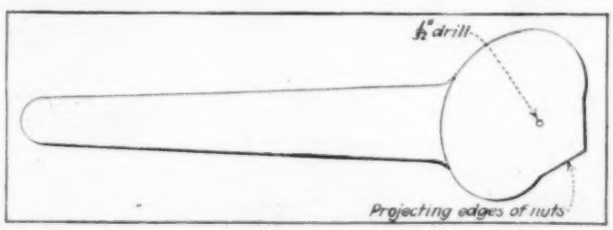
The department, "Ideas from Practical Men," is devoted to the exchange of information on methods useful to the machinery industries. It includes all divisions of engineering practice, from design problems to engineering equipment. Descriptions of methods or devices that have proved their value are carefully considered, and those published are paid for. The rates are from a minimum of five dollars upwards, depending upon their merit.

An Aid to Checkers

By Samuel Kauffman

As an aid in checking assembly drawings, I have found the use of model wrenches made to the same scale as that of the drawing of great assistance. The models are made of celluloid, and instead of openings they have the projecting edges of the nuts extending from the jaws. By placing the proper model over the outline of a nut, or a hex-head capscrew, it can be seen whether or not there is sufficient clearance for the wrench to turn freely, both in tightening or loosening the nut, or screw, and in moving it from one gripping position to another. Thus, any interference due to projecting parts of the machine or to insufficient room in pockets can easily be discovered. Also, the type of wrench best suited for the particular purpose can be determined.

As shown in the illustration, a $\frac{1}{32}$-in. hole is drilled



Model wrench made of celluloid

where the center of the screw, or nut, would be, so that the model can be properly located on the drawing. The outlines and dimensions for sets of wrenches can be found in nearly all of the handbooks.

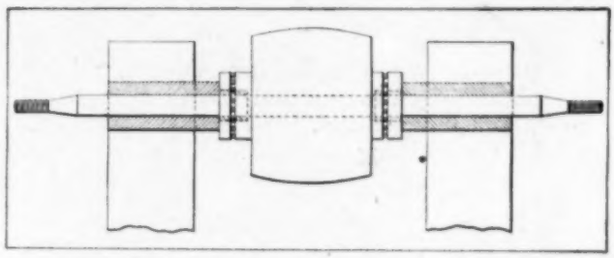
Improvement in Grinder Collars
Discussion

By C. L. Henry
Nottingham, England

The improved, adjustable collar for a grinding machine described by Edwin Kilburn in an article under the title given above, on page 484, Vol. 70, of the *American Machinist*, reminds me of another method of preventing end motion in grinder spindles. The arrangement shown by the accompanying sketch has been running successfully for the past three years without adjustment.

Two ball thrust-bearings are fitted, one on each side of the pulley, on the spindle bearings of a Brown & Sharpe tool grinder. They are a snug fit between the shoulders of the turned-down bronze bearings and the faces of the pulley hub. The bronze bearings are adjustable endwise in the housings, so that all end motion of the spindle can be taken up by moving them inwardly.

With the machine so fitted, we have been able to grind steel components on a production basis with a high degree of accuracy, using a cup wheel and a simple type of holding fixture. In fact, we are grinding work to within ±0.0005 in. in two operations, leaving from 0.001 to 0.002 in. for finishing between operations. Thus, the



Use of ball bearings to control end motion

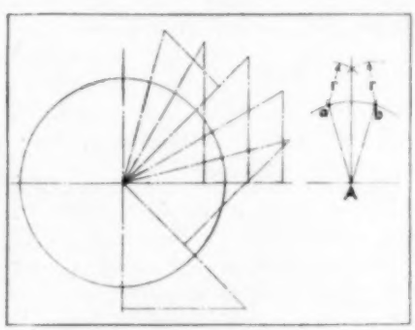
machine has been turned into a rapid, accurate production-grinder.

When assembled to the machine, the ball bearings should be filled with a good type of grease. The existing guard on the machine prevents dust and dirt from getting into them.

Laying Out Angles Without a Protractor
Discussion

By W. R. Needham
English Electric Company, Ltd.

On reading the article by J. Staveley, under the title given above, on page 751, Vol. 70, of the *American Machinist*, I was reminded of the method here described of using 30- and 45-deg. triangles for subdividing a right angle into two, three or six equal angles. By the same means, a circle can be subdivided into eight, twelve or twenty-four equal sectors. As the illustration shows, it is a simple matter to further divide these subdivisions by the use of dividers. The eye can be trusted to guide to a close guess, therefore, two or three trials with the dividers should suffice to obtain the correct chord.



Method of laying out angles without a protractor

In any case, unless the angle is a large one, an admirable starting point is the arc of the circle as determined by slide-rule calculations. For small angles, of course,

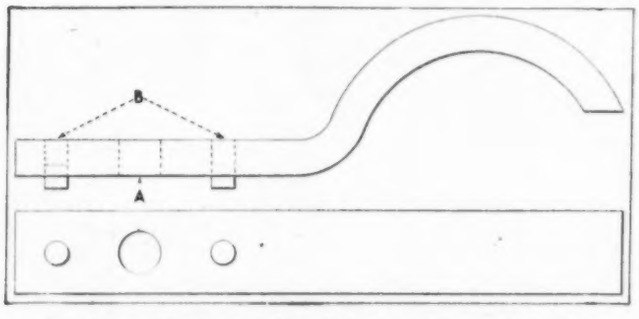
the difference between the arc and the chord is very small. Thus if N subdivisions are required in a circle of D inches diameter, then the arc required between divisions will be equal to $\frac{3.1416}{N} \times D$ inches. Using this formula, where conditions permit, in conjunction with the subdividing method suggested, often lessens the work.

The well-known method of bisecting an angle, as shown at A, is often useful. The two radii struck from centers a and b, respectively, are equal. The intersection of the curves locates the bisecting radial, therefore the sub-angles are equal.

Eliminating Pins for Locating Purposes

By Charles Kugler
General Electric Company, Philadelphia

The stamping shown in the illustration was located on an assembly by two pins and was held in place by a screw through the hole A. The cost of assembly was lessened by eliminating the pins. The holes usually



Projections left by punching half-way through the metal

punched for the pins are now punched only half-way through, leaving the projections B on the under side.

The projections fitted into the holes in the casting to which the part was assembled and served the same purpose as did the pins formerly used. The only alteration to the punches was to shorten them so that they would go only half-way through the metal, while the punch for the screw hole would go all the way through.

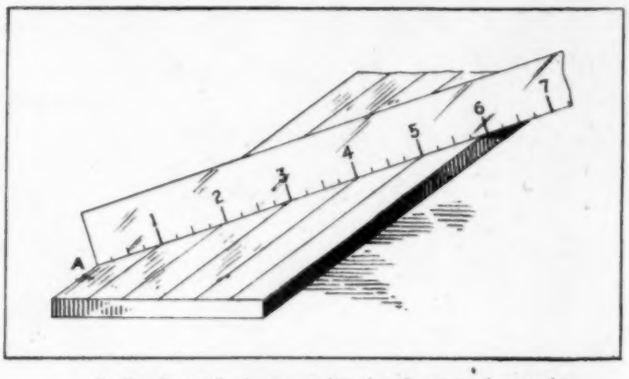
Method of Dividing by the Use of a Scale

By Don R. Hammitt
Chief Engineer, Portland Forge & Foundry Company

The method of dividing, shown in the illustration, will be found useful for layout work on the drafting board or in the toolroom. With its use, it is not necessary to consider the width of the part to be laid out, but only the number of spaces required.

A scale of any length may be used, provided that it is long enough to go across the piece to be laid out. In the example shown, it is required to divide a block 4 in. wide into six equal parts. To do this, one end of the scale is placed at one edge as at A, and it is then laid across the face of the block until the figure 6 coincides with the opposite edge.

It is then only necessary to scratch a mark at each division on the scale, which gives six equal spaces. Should the layout require more spaces than can be measured by inch graduations, the $\frac{1}{2}$- or $\frac{1}{4}$-in. divisions on the scale can be used. Had the $\frac{1}{2}$-in. graduations in the example shown been used, there would have been 12



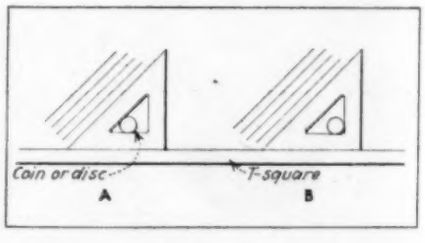
A simple method of spacing by the use of a scale

equal divisions. This method will be found much faster than using dividers for spacing, and will save much time in figuring, especially where the width of the piece is fractional.

Method of Cross Sectioning

By Roy E. Peterson

The method of cross-sectioning shown in the illustration, I believe is the simplest and most accurate, where a special instrument is not available. When a small triangle is used, a coin may act as the gage, and for larger triangles a cardboard disk works well. To cross hatch, a coin or disk, as required, is placed in the opening of the triangle as far to the left as possible as shown at A, draw the line and move the coin to the right as far as possible as at B. Bring the triangle to the right to meet the coin and draw the next line. Draftsmen will find this operation easy after a few lines have been made, and the results are almost equal to those obtained from a mechanical cross hatching device. This method also has the advantage of allowing the draftsman to cross section line with ink in the first operation. It is easily operated with one hand.



Cross-sectioning device

Repairing Drawing Boards

By George F. Watt
Chief Draftsman, Pope Machine Company

As a means of increasing the life of a drawing board, we have found it practical to fill the corners, where the thumbstacks have honeycombed them, with plastic wood, which may be purchased at any hardware store. It sticks well and fills the holes, so that a smooth surface is retained on the board, while at the same time it does not crack out when a tack is driven in, as is the case with putty.

Stub Spur Gear Diameters

With Working Clearance or Running Allowance Made

Number of Teeth	6/8 Pitch Root Diameter	6/8 Pitch Pitch Diameter	6/8 Pitch Outside Diameter	8/10 Pitch Root Diameter	8/10 Pitch Pitch Diameter	8/10 Pitch Outside Diameter	10/12 Pitch Root Diameter	10/12 Pitch Pitch Diameter	10/12 Pitch Outside Diameter
12	1.678	2.000	2.241	1.243	1.500	1.693	0.986	1.200	1.361
13	1.845	2.167	2.408	1.368	1.625	1.818	1.086	1.300	1.461
14	2.011	2.333	2.574	1.493	1.750	1.943	1.186	1.400	1.561
15	2.178	2.500	2.741	1.618	1.875	2.068	1.286	1.500	1.661
16	2.345	2.667	2.908	1.743	2.000	2.193	1.386	1.600	1.761
17	2.511	2.833	3.074	1.868	2.125	2.318	1.486	1.700	1.861
18	2.678	3.000	3.241	1.993	2.250	2.443	1.586	1.800	1.961
19	2.845	3.167	3.408	2.118	2.375	2.568	1.686	1.900	2.061
20	3.011	3.333	3.574	2.243	2.500	2.693	1.786	2.000	2.161
21	3.178	3.500	3.741	2.368	2.625	2.818	1.886	2.100	2.261
22	3.345	3.667	3.908	2.493	2.750	2.943	1.986	2.200	2.361
23	3.511	3.833	4.074	2.618	2.875	3.068	2.086	2.300	2.461
24	3.678	4.000	4.241	2.743	3.000	3.193	2.186	2.400	2.561
25	3.845	4.167	4.408	2.868	3.125	3.318	2.286	2.500	2.661
26	4.011	4.333	4.574	2.993	3.250	3.443	2.386	2.600	2.761
27	4.178	4.500	4.741	3.118	3.375	3.568	2.486	2.700	2.861
28	4.345	4.667	4.908	3.243	3.500	3.693	2.586	2.800	2.961
29	4.511	4.833	5.074	3.368	3.625	3.818	2.686	2.900	3.061
30	4.678	5.000	5.241	3.493	3.750	3.943	2.786	3.000	3.161
31	4.845	5.167	5.408	3.618	3.875	4.068	2.886	3.100	3.261
32	5.011	5.333	5.574	3.743	4.000	4.193	2.986	3.200	3.361
33	5.178	5.500	5.741	3.868	4.125	4.318	3.086	3.300	3.461
34	5.345	5.667	5.908	3.993	4.250	4.443	3.186	3.400	3.561
35	5.511	5.833	6.074	4.118	4.375	4.568	3.286	3.500	3.661
36	5.678	6.000	6.241	4.243	4.500	4.693	3.386	3.600	3.761
37	5.845	6.167	6.408	4.368	4.625	4.818	3.486	3.700	3.861
38	6.011	6.333	6.574	4.493	4.750	4.943	3.586	3.800	3.961
39	6.178	6.500	6.741	4.618	4.875	5.068	3.686	3.900	4.061
40	6.345	6.667	6.908	4.743	5.000	5.193	3.786	4.000	4.161
41	6.511	6.833	7.074	4.868	5.125	5.318	3.886	4.100	4.261
42	6.678	7.000	7.241	4.993	5.250	5.443	3.986	4.200	4.361
43	6.845	7.167	7.408	5.118	5.375	5.568	4.086	4.300	4.461
44	7.011	7.333	7.574	5.243	5.500	5.693	4.186	4.400	4.561
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48	7.678	8.000	8.241	5.743	6.000	6.193	4.586	4.800	4.961
49	7.845	8.167	8.408	5.868	6.125	6.318	4.686	4.900	5.061
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63	10.178	10.500	10.741	7.618	7.875	8.068	6.086	6.300	6.461
64	10.345	10.667	10.908	7.743	8.000	8.193	6.186	6.400	6.561
65	10.511	10.833	11.074	7.868	8.125	8.318	6.286	6.500	6.661
66	10.678	11.000	11.241	7.993	8.250	8.443	6.386	6.600	6.761
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97	15.845	16.167	16.408	11.868	12.125	12.318	9.486	9.700	9.861
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99	16.178	16.500	16.741	12.118	12.375	12.568	9.686	9.900	10.061
100	16.345	16.667	16.908	12.243	12.500	12.693	9.786	10.000	10.161

Contributed by A. Wasbauer, Standardization Engineer, The Ingersoll Milling Machine Company

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Who Gets the Engineer?

RECENTLY one of the largest electrical manufacturers announced that it had in its employ more than 4,400 college graduates, the majority of whom had engineering degrees. Analysis showed that these men held all kinds of positions from assistant shop foremen to managers, but that by far the greater proportion were located on actual engineering work.

Apparently the big plant finds it profitable to employ a high ratio of trained engineers in proportion to total employees. In fact, this may be one of the factors that is making the big plants today so outstanding in the most modern methods and highly developed product. There is certainly a great deal of truth in the ancient maxim that wise men depend on reason and men of less understanding on experience. These great manufacturing plants are depending on research and intelligent design by engineers who are trained to reason, and the success of their products on the market can be attributed largely to its excellence.

If the small shop is to live and compete successfully with the big plant, it must adopt the best ways of the big shop. Fortunately there has been a decided tendency lately for the small shop to take in the trained engineer, but recent figures from Purdue, which may be considered as representative, show less than thirty per cent of its graduates going to small companies. The small company needs the trained engineer as much as the big plant if it intends to meet modern competition, and this percentage must increase.

*

Magnesium Comes Into Its Own

IT WAS not along ago that practically the only uses for the metal magnesium were for medicinal compounds, fireworks, and flashlight powder. Then came its cautious use in light alloys for the automotive industry, chiefly in pistons. Now, the research engineer, to meet the demands from the new aircraft industry, has produced alloys composed basically of magnesium, which have high strength and are a third lighter than aluminum.

Within a relatively short time ultra-light magnesium alloys have been made commercially possible, and have been placed on the market in castings, forgings, extruded shapes, and sheets. The old fire hazard of the metal has been largely removed, mechanical strength has been obtained by alloying, and physical properties improved by heat-treatment. These results have not been obtained by chance, but by careful research working for definite objects, much of the research being done in the laboratory. Cast aircraft engine crankcases, forged propellers, and many other parts made from magnesium alloys with more than ninety per cent of magnesium have proved sufficiently the worth of the metal for mechanical construction. An entirely new group of alloys, therefore, giving many desirable properties, besides light weight, has been made available to the machine designer by modern engineering research.

*

Interchangeability With Flanged Motors

BUILDERS of nearly all classes of machines employing electric motors for direct or other positive drives, and to a lesser extent for belt drives, long have desired motors that are mechanically interchangeable, especially as between alternating and direct current types of about the same rating. Today such motors ordinarily are not mechanically interchangeable except in fractional-horsepower sizes.

According to C. E. L. Dapprich, General Engineer of the Westinghouse Electric and Manufacturing Company, such interchangeability is readily accomplished by the use of flange mounting, instead of foot or pedestal mounting. In addition, flanged motors have the advantage that they can be mounted on or partly inside the machine, thereby saving floor space and often the cost of a special platform or bracket. In general, the combined cost of the machine and motor is reduced.

Again, the appearance of the combined units is likely to be improved. The assembly frequently has a more finished look, as if the motor had been "designed into" the machine rather than "stuck on," to use expressive phrases.

Flanged motors are not new, but the number of new applications appears to be increasing, for good reasons. A variety of these will be illustrated in a later number, and the views of engineers who have studied the subject will be quoted.

NEW MATERIALS AND PARTS

And Engineering Equipment

"Durimet" Corrosion-Resistant Steel

A CORROSION - RESISTANT steel intended to resist the action of hot weak solutions of sulphuric acid is being marketed under the name of "Durimet" by the Duriron Company, Inc., Dayton, Ohio. Three varieties of the steel are available listed as "A", "B", and "D", all containing high percentages of nickel and silicon. Durimet A contains 25 per cent nickel, 5 per cent silicon, a trace of chromium, and 0.25 per cent carbon. Durimet B contains 35 per cent nickel, 5 per cent silicon, 12 per cent chromium, and 0.25 per cent carbon. Durimet D contains 15 per cent nickel, 3 per cent silicon, 2.5 per cent chromium, and 0.60 per cent carbon.

PHYSICAL CHARACTERISTICS

The physical characteristics of the Durimet grades vary slightly with different compositions. Durimet A has a tensile strength of 100,000 lb. per sq.in., as rolled, and 90,000 lb. per sq.in. when quenched from 2,030 deg. F. It has a hardness of 160 Brinell as rolled and 121 quenched from 2,030 deg. F. The physical characteristics of Durimet B are practically the same as those of A. Durimet D castings have a tensile strength of 75,000 lb. per sq.in., and a yield strength of 48,000 lb. per sq.in. None of the Durimet grades will machine as readily as carbon steels and cutting speeds for them must be somewhat slower than in ordinary practice. All grades are austenitic and practically unhardenable by heat-treatments. For this reason there is no difficulty in making satisfactory welds, not only from a mechanical standpoint, but also from the standpoint of resistance to corrosion.

The A and B grades can be furnished in the form of hot- or cold-rolled bars, sheets and plates, ground and polished shafting, wire, rivets, bolts and nuts, and castings. The D grade, at the present time, is only furnished in the form of castings. This grade casts very readily, is quite fluid while molten and does not require special pattern design. The A grade can be recommended for use in the manufacture of alum and to handle alum solutions and for similar work with acid. It is not resistant to nitric acid, atmospheric corrosion, or other oxidizing conditions. The B grade is slightly more resistant to hot weak sulphuric acid than the A grade. This metal shows good resistance to hot glacial acetic acid and can be used for ventilating fans and ducts, towers, and similar equipment handling entrained sulphuric acid and laboratory fumes. The D grade has approximately the same acid-resistant qualities as the A grade.

One application of Durimet is in the construction of pickling tanks. It may also be used for pickling crates, pins, sling chains, link chains for bar picklers, pickling barrels, baskets and, in fact, all the equipment used in sulphuric acid pickling.

Allen-Bradley Bulletin 825 Overload Breakers

A complete line of Bulletin 825 overload breakers for fractional-horsepower d.c. and a.c. single-phase and polyphase motors has been announced by the Allen-Bradley Company, 286 Greenfield Ave., Milwaukee, Wis. Protection is afforded by the breakers against motor burnouts and damage to the driven machines from overloads. The breakers have a maximum rating of 1 hp. at 125 volts and 1½ hp. at 220 volts, and may be obtained with or without a snap switch or fuse clips. Six forms have been developed for various industrial applications.

Allen-Bradley Bulletin 825 Overload Breakers for Small Motors

"Swedelec" High-Permeability Iron

An iron claimed to have high permeability and low hysteresis loss is being imported by A. Milne & Company, 745 Washington St., New York. The material is a Swedish charcoal, Lancashire iron product adapted for core parts where high permeability and low hysteresis loss are essential. The iron is a wrought or puddled metal and possesses altogether different properties from ingot metal. It may be used by manufacturers of railway signals, automatic safety control equipment, telephone switchboard equipment and similar parts. It is obtainable in cold-drawn rounds, squares, flats, special shapes, and in cold-rolled, dead-soft annealed strips. Sizes for rounds and squares vary from $\frac{1}{64}$ to 3 in., and for cold-rolled strips, from 0.410x3 in. wide to 0.250x6 in. wide.

"Rustless" Chrome-Iron Alloys

A series of four brands of rustless iron known as "Defirust," "Special Defirust," "Defistain," and "Defiheat," are being manufactured by the Rustless Iron Corporation of America, 122 East 42d St., New York, N. Y. The four brands are chromium-carbon alloys, and, as their trade names indicate, are manufactured for corrosion resistance, all of them containing a high percentage of chromium and a very small amount of carbon. The manufacturers claim for this iron homogeneity unusual for this type and also softness, malleability, and ease of cold working. They also claim that a finished surface of the material may be easily

brought to a high luster, and that the material is free from impurities.

Defirust contains 12 to 14 per cent of chromium, Special Defirust contains 16 to 18 per cent of chromium, Defistain contains 17 to 19 per cent of chromium, and Defiheat contains 25 to 30 per cent of chromium. Defirust only attains full resistance when properly polished. Special Defirust is highly corrosion resistant without polishing. Defistain will resist certain acids where Defirust and Special Defirust will fail. Defiheat has a resistance to corrosion higher than Defistain, but much greater heat resistance. Defistain and Defiheat are comparatively difficult to machine, but are also the two toughest of the four brands. All brands of the iron are furnished in the standard shapes and sizes.

REVIEW · OF · RECENT · PATENTS

Relating to the Machinery and Metal Products Industries

Parts and Mechanisms

Frederick M. Becket, of New York, N. Y., has been allowed patents 1,720,312 and 1,720,313 relating to anodes for chromium plating, the first comprising chromium and about 0.5 to 7 per cent of carbon, and the second comprising chromium and about 0.25 to 35 per cent of silicon, used in an aqueous solution of chromic acid.

To Gaylord H. Halvorson, of Duluth, Mich., has been issued patent 1,720,327 on a silica crucible with double walls and silica covers for the inner and outer compartments.

A holddown mechanism for shearing machines, operated by a system of levers, toggles and rods, is the subject of patent 1,722,819, assigned to the Niagara Machine & Tool Works.

Donald H. West, of New London, Conn., has been granted patent 1,722,832 on a hydraulic transmission with a wabble plate mechanism, the angle of which can be varied, thereby varying the stroke of the pistons.

To the Endicott-Johnson Corporation has been assigned patent 1,722,853 for a buffing wheel hood with a novel arrangement of louvers and baffles, and means for regulating the suction in the hood.

Materials

To the Westinghouse Lamp Co., has been assigned patent 1,724,134, relating to a wire-drawing lubricant comprising powdered graphite and a gelatinous suspending medium composed of agar-agar dissolved in water and turkey red oil.

Jacob Laeufer, of Detroit, Mich., has been granted patent 1,724,718 on a brake lining consisting of finely divided fibrous matter, a hydraulic cement and a heat-resisting agent composed of asbestos, a sodium compound, blood, and casein.

A brazing alloy containing about 54 per cent copper, about 36 per cent zinc, and an appreciable amount, but not substantially more than 10 per cent of silver, is covered by patent 1,724,818, assigned to the General Electric Company.

A coating for molds, which contains particles of chromium, a woven organic material, and an oxidation inhibitor, and which is adopted to form a homogeneous surface material alloyed with a base-material, is the subject of patent 1,725,039, assigned to the Electro Metallurgical Company.

Patent 1,725,445, assigned to the General Plate Co., relates to a plate with gold surface portions on a backing of copper-aluminum alloy, that is capable of attenuation by cold rolling or drawing. The backing contains from 2 to 10 per cent of aluminum.

TRADE PUBLICATIONS

AMMETERS. The Roller-Smith Co., 233 Broadway, New York City, has published Bulletin No. 810, covering its Types TW, FW, and STW thermocouple ammeters and milli-ammeters for d.c. and a.c. circuits of all frequencies.

CHAIN BELTS. The Diamond Chain & Manufacturing Co., Indianapolis, Ind., has published booklet No. 104 entitled "Simplifying and Improving Machine Design," which is devoted to a discussion of the application of chain drives to various kinds of machinery.

DIE CASTINGS, ZINC. The New Jersey Zinc Co., 160 Front St., New York City, has issued a booklet entitled "Horse Head Zinc in Die Castings," which illustrates uses of zinc die castings throughout industry. The booklet is mainly a series of illustrations with only such explanations as may be necessary to explain the cuts.

LUBRICATION, INDUSTRIAL PLANT. E. F. Houghton & Company, Philadelphia, Pa., has issued a booklet entitled "Houghton on Industrial Plant Lubrication." The booklet describes the absorbed oils and "cosmolulrics" manufactured by the company and gives their applications in industries. The booklet is illustrated and also gives a list of Houghton distributors. It contains 56 6x9-in. pages.

RARE METALS. The Fansteel Products Co., Inc., North Chicago, Ill., has prepared a bulletin entitled, "Rare Metals," which is devoted to the history, properties, and uses of the metals tantalum, tungsten, and molybdenum. The catalog is replete with illustrations of the uses of these rare metals in the various industries. There are many tables on wire data and corrosion-resistance of the metals.

S.A.E. STEELS, MICROSTRUCTURE OF. E. F. Houghton & Company, Philadelphia, Pa., have issued a book entitled "Microstructure of S.A.E. Steels After Recommended Heat-Treatment." The booklet contains a number of photographs of the microstructure of S.A.E. steels after heat-treatment. Brinell hardness tables and a list of tables of recommended heat-treatments for the various S.A.E. steels are included in the book, which also has a number of other tables. The book contains 56 8½x11-in. pages.

STEELS, TOOL AND ALLOY. Joseph T. Ryerson & Son, Inc., Chicago, has issued a handbook entitled "Tool and Alloy Steels," which contains several articles on choosing, forging, annealing, and treating steels, a list of the various tool and alloy steels available, and the work for which they are suited. The booklet also contains a number of tables and is indexed. It contains 128, 4½x7½-in. pages.

"TEXROPE" DRIVES. The Allis-Chalmers Manufacturing Co., Milwaukee, Wis., has published Machine Tool Leaflet No. 1236-A which indicates the advantages derived by the use of "Texrope" drives on various classes of machine tools. The pamphlet, well illustrated throughout, contains nineteen 10½ x 8-in. pages.

TRANSMISSIONS, VARIABLE SPEED. The Reeves Pulley Company of New York, Inc., 76 Dey St., New York, has published Catalog No. 88, describing the Reeves Variable Speed Transmission. Descriptive matter, cuts, and tables are included to show the operation and construction of the transmission and its applications. A table of transmissions is given, listing all sizes from fractional to 150 hp. in ratios of from 2 to 1 up to and including 16 to 1, giving power capacities, speeds and other pertinent data regarding each. The catalog contains sixty-four, 7¾ by 10¾-in. pages.

NEWS
OF THE WEEK

Machine Tool Show with 200 New Exhibits Draws Over 25,000 Attendance

THE second National Machine Tool Builders' Exposition, held in Cleveland from September 30 to October 4, attracted a record-breaking attendance of over 25,000 engineers, executives and production men from practically every type of metal-working industry in the country. In addition there was a good representation from several of the foreign industrial countries, notably England, France, Belgium, Germany and Czecho-Slovakia.

The opinion was unanimous that it was a "great Show." Although anticipating a few outstanding developments, scarcely anyone who inspected the exhibits was prepared for the remarkable demonstration of progress in machine design which has been made in answer to the demands of industry for high-production equipment. About 200 new items of equipment were on display.

Among the chief features was the application of tungsten-carbide cutting tools to the machines of some 40 or more exhibitors at the Show. In one instance a bar of UMA5, 1 per cent chromium, 0.5 per cent carbon steel, about 6 in. in diameter, and of 320 Brinell hardness, was cut at a speed of 320 ft. per min., with a 0.012 in. feed. The depth of cut was $\frac{5}{8}$ to $\frac{3}{4}$ in. Under these conditions high-speed steel tool gave out in 10 sec. and actually melted so that a small globule appeared on the cutting edge. The tungsten-carbide-edge tool stood up without regrinding until a 14-in. length of bar had been cut. The chip was a brilliant red at the cutting edge and a cherry red for 18 in. from the point of the tool. Other exhibits demonstrated a tremendous cutting speed on cast iron and other metals.

Definite accomplishment has been registered in the speeding up of equipment of all kinds. Also, high production is being obtained on almost every type of equipment by the introduction of automatic features, centralized control at the operator's position, abundant lubrication quite often of the automatic type, and the liberal application of low-friction bearings, mainly of ball or roller type. The growing application of hydraulic feed is especially noteworthy. Motor-drive is now almost universal, with leather belts, cog belts, Texrope, or silent chain drives used largely for the transmission of power to working spindles and mechanisms. These and other trends have been discussed previously in Vol. 71, p. 472, of the *American Machinist*.

Few actually radical changes in the design of machines were evident at the Show. There has been rather a refinement of detail, making the machines easier to handle, increasing cutting time and decreasing idle time.

In connection with the Show there were held sessions of the Machine Tool Congress, in conjunction with the Machine Shop Practice Division of the A.S.M.E. and the Production Division of the S.A.E. The A.S.M.E. Machine Shop Practice Division sponsored the Monday evening meeting, presided over by Phillip E. Bliss, president of the Warner & Swasey Co., on the subject of "What Information Does the Machine Tool Buyer Need from the Machine Tool Salesman?", at which the paper was presented by George T. Trundle, Jr., president of the Trundle Engineering Co., Cleveland. This division also handled the Tuesday evening meeting on the "Present Status of Tungsten-Carbide Tools and Dies," at which Dr. Zay Jeffries of the General Electric Co. presented a paper, and Ralph E. Flanders, general manager of the Jones & Lamson Machine Co., presided. Mr. Trundle analyzed his topic under the five headings of "who, what, when, where and why." He stressed the necessity for the buyer to purchase from a reliable firm, to know that he is protected in case the machine he acquires infringes a patent, to be informed as to its production possibilities, to interpret facts regarding his own use of the machine from the ideal cases naturally cited by the maker, the range of speeds and feeds, method of lubrication, kind of tools to be used, and similar factors. Among his recommendations were that machines should not be expected to return their cost in one year, and that the reserve set aside as depreciation on equipment be kept in liquid form for replacement purposes.

Dr. Zay Jeffries in his address summarized the technical developments made in tungsten-carbide cutting tools. In one case of wire-drawing the increase in economy was 6 to 1, in rough and finishing turning of armatures the new tools give 30,000 per grind as against 150 with high-speed steel. In profiling 1,020 S.A.E. steel 25,000 pieces per grind were obtained, as against 60 before. One tool sold fifteen months ago is still operating and has replaced 2,450 lb. of tool material formerly used.

The S.A.E. meeting on Wednesday evening, presided over by E. P. Blanchard, assistant sales manager of the Bullard Machine Tool Co., was well attended. Fairfield E. Raymond, assistant professor of industrial research in the department of economics at the Massachusetts Institute of Technology, presented the results of his production study of the automotive industry during the past summer in a paper on "Manufacturing Control Through Economic Size of Production Lots," reviewed on page 669 of this issue of the *American Machinist*. The Thursday evening round table discussion under the sponsorship of the S.A.E., presided over by A. K. Brumbaugh of the White Motor Co., was a production forum.

At the Production Dinner which closed the proceedings for the week, E. P. Blanchard, of the Bullard Machine Tool Co., and chairman of the S.A.E. production committee, acted as toastmaster. The only speaker was James Schermerhorn, Sr., founder of the *Detroit Times*. After releasing a flood of stories that led his hearers to believe that amusement was his sole purpose, he suddenly became serious and expressed his conviction that the formation of a United States of Europe was imminent, and that it would be followed by a United States of the World.

In closing the meeting Mr. Blanchard announced that John Younger, professor of industrial engineering at Ohio State University, and a former associate editor of the *American Machinist*, had been selected to head the Production Division of the S.A.E. Under the new organization plan of the society the head of this division is a vice-president.

* * *

National Safety Congress Attended by 7,500

Approximately 7,500 delegates attended the National Conference of Safety Experts during the past week in Chicago. They came from all parts of the United States and a few came from abroad. The convention lasted for five days and dealt with industrial and home accidents as well as those occurring in traffic. A number of exceptional papers were presented in the 22 meetings of various sections daily.

A. M. Williams, supervisor of safety of the Chrysler Corporation, Detroit, in his talk before the automotive section on Oct. 1, explained the importance of the worker in safety progress in a talk entitled "Letting the Worker Educate the Safety Man." Mr. Williams believes that workers' opinions should be asked on how and why certain things should be done to promote safety. If

the worker's opinion is asked, he will remember better, will think about it and will develop what is known as a "safety habit." Conferences are also of considerable importance in developing the habit, if the safety man and those in charge do not monopolize the time. Another suggestion was that the treadle be eliminated on large presses and two push buttons be substituted for it to eliminate fatigue. The annual banquet of the Council was held on Wednesday evening, Oct. 2, in the grand ballroom of the Stevens Hotel.

* * *

Standard for Taps Proposed by A.S.M.E.

Copies of the proposed American Standard for cut and ground thread taps, recently completed by the A.S.M.E., are now being distributed for criticism and comment. Particular features of the proposed standard are the adoption of larger major diameters to allow for greater wear, increase in minimum pitch diameters on cut thread taps over ¼-in. diameter to compensate for lead error, adoption of a comprehensive standard for ground thread taps and standardization of a number of elements not heretofore covered. Copies of the proposed standard may be obtained from C. B. LePage, assistant secretary of the A.S.M.E., 29 West 39th St., New York, N. Y.

* * *

Issue Simplification On Diehead Chasers

A request for acceptance of the report of the Division of Simplified Practice of the U. S. Department of Commerce on diehead chasers has been issued to manufacturers, distributors, and users. The simplified practice recommendation covers self-opening and adjustable dieheads for all the various threads at present in use. This simplified practice recommendation is an effort to eliminate waste by discontinuing the production of a number of specials. It was developed by the diehead chaser industry on its own initiative.

* * *

Standards Association Makes Study of Drills

A technical committee on standardization of twist drill sizes of the American Standards Association has conducted an intensive study of 138 drill sizes carried in stock by the various drill manufacturers and users in the size range from No. 80 to ½ in. inclusive. As a result of the study, the committee has prepared two proposals, covering diameter and length, which are considered satisfactory for use by industry. The proposals are now being circulated for review among users of these drill sizes to determine which are preferred. Copies of the proposals may be borrowed through the A.S.A. office at 29 West 39th St., New York.

Machines Replace Men In Building Trade Mart

Machinery has displaced manpower and hand tools wherever possible in the building of the Merchandise Mart, the world's biggest business building, now being erected at Wells St. and the Chicago River, Chicago. Cement, which is transported in bulk form by boat to the building site, is shot by compressed air to a height of 75 ft. to a mammoth bin. Gravel and sand are elevated mechanically from railroad cars to another bin. Materials are fed by gravity into mechanical mixers. Endless belt conveyors convey wet concrete throughout the building. Railroad tracks running directly into the building bring in building materials. Railroad cranes unload the steel beams and nine guy derricks hoist them to their places. A well-organized job mill, containing a full quota of woodworking machinery, is used to prepare woodwork for forms and other purposes.

* * *

Iron Alloys Study To Last Five Years

A committee headed by Dr. George B. Waterhouse, professor of metallurgy at the Massachusetts Institute of Technology, will inquire into all basic data on iron and its combinations with other metals, in a program of research sponsored by the Engineering Foundation. It is planned to spend five years and $150,000 on the initial stage of the research work, in which the committee will have the co-operation of the engineering societies, universities, and the Government. On its efforts it is said depends the ability of the American iron and steel industry to maintain a strong position in alloy irons and alloy steels.

Assisting Dr. Waterhouse on the committee will be Dr. George K. Burgess, director of the U. S. Bureau of Standards; Scott Turner, director of the U. S. Bureau of Mines; R. E. Kennedy, secretary of the American Foundrymen's Association; Dr. H. W. Gillette, director of the Battelle Institute; Dr. Bradley Stoughton, director of the Metallurgical Engineering department of Lehigh University; Jerome Strauss, chief research engineer of the Vanadium Corporation of America; T. H. Wickenden, metallurgical engineer of the International Nickel Co.; and Dr. John A. Mathews, vice-president of the Crucible Steel Co. of America.

* * *

Will Show Many Tools At Salesmen's Exhibit

Many manufacturers of small tools and steels are included among the 123 exhibitors at the co-operative exhibit of the Salesmen's and Purchasing Agents Association, Inc., which is to be held in Bridgeport, Conn., Oct. 17 to 19. The exhibit is an association of buyers and sellers brought together for mutual understanding and demonstration of the latest developments in various fields.

* * * *

Metals Market Maintains Stability With Demand Slow and Prices Low

REPLACEMENT of the fading Age of Iron by the new "Alloy Age" is evidenced by several events during the past month, notably the unprecedented demand for alloys. This trend of events was strikingly illustrated in the National Metals Exposition in Cleveland recently and again at the National Machine Tool Builders' Exposition held there last week. High-speed cutting alloys, corrosion-resistant steels and irons, lightweight alloys of high tensile strength, die-casting alloys, and alloy welding rods particularly, are being more widely applied today than ever before. Tungsten, chromium, nickel, vanadium, cobalt, and manganese are the chief metals involved in the numerous alloy steels. Nickel, silicon, manganese, and copper are being used to make the light-weight aluminum and magnesium alloys which have greater strength than the best steels of a few years ago.

Comparatively rare and little-known metals have suddenly assumed an importance in the market as the result of the development of alloys. Chief among these are tantalum, selenium, molybdenum, cadmium, cobalt, tellurium, chromium, and vanadium.

Tin, which is now selling at 44 cents, has been dropping steadily since early in 1927, when it was selling at approximately 74. The price drop makes the metal more available for use in plating and babbitt-making and may be an effort to regain the market lost to cadmium in the finishing field and to antimony- and lead-base babbitts in babbitting. Copper is holding firm with a price of 17.775 cents. Sales have improved somewhat, with over half the business for prompt or October shipment.

Zinc has been exceedingly dull but the full price of 6.80 cents seems to have been quoted by all sellers and have been realized on such business as was done. Lead transactions made a good showing compared with the other non-ferrous metals, sales for the period being close to the average in volume. Prices were firm but unchanged at 6.9 cents in New York, and 6.7 in St. Louis. Magnesium varied between 95 and $1.05 a pound, depending on quantity. Molybdenum, 99 per cent, was selling at $18 a pound. Other metals were maintaining their prices about where they have been. Tantalum, selling at about one-quarter the price of gold, is being used for difficult corrosion problems. Antimony has been irregular during the past month.

Rapid Progress in Aeronautical Design Evidenced by Events of September

NOTEWORTHY events of the past month in the aeronautical industry embraced a wide variety of accomplishments, notably the completion of the comparatively large Fokker 34-passenger land plane, the Consolidated *Commodore*, largest American flying boat, and the successful operation of the ZMC-2, all-metal dirigible. Also worthy of mention are the flight of Fritz Von Opel in a rocket-propelled airplane, the development of a German motor propelled by liquid gas jets, and the announcement of design innovations in entries submitted for the Guggenheim safe aircraft competition. Re-design of aircraft control instruments has also enabled an Army flyer, Lieut. J. H. Doolittle, working under the sponsorship of the Guggenheim fund for the promotion of aeronautics, to make a successful "blind" flight, guided entirely by instruments in an inclosed cockpit out of which he could not see.

Designed for Transcontinental Service

Designed for transcontinental passenger service, the Fokker plane is the first of five which will be used by the Universal Air Lines. The plane, known as the F-32, has accommodations for 30 passengers and a crew of pilot, co-pilot, radio operator, and steward. It has 32 seats, 30 for the passengers and two for the pilots, while the radio operator and steward are given space in the pilot seats and the control cockpit. Divided into four sections, the passenger cabin is finished in mahogany. Each section has four glass windows. The equipment is so arranged that the cabin can be converted into sleeping compartments for sixteen persons.

The F-32 is of standard Fokker design, with a veneer covered wing of full cantilever type. The fuselage tail surfaces and the landing gear are of tubular steel construction. Aluminum gasoline tanks of a total capacity of 700 gallons are placed between the wing spars, with visible gasoline-level gage glasses. Four, 15-gallon oil tanks are placed in the nacelles, one double tank in each nacelle.

Divided-type landing gear, 20 ft. wide, is used, with axles hinged to the bottom of the fuselage. Its roller-bearing wheels with internal expanding brakes are fitted with 58 x 14-in. tires.

A maximum speed in sea-level country of 140 miles an hour, and a cruising speed of 120 miles per hour were used as a basis for design. The ship has dual wheel control, adjustable, with the brakes acting independently on each wheel, so that the plane can be steered readily on the ground. When empty, the plane weighs 13,800 lb., can carry a useful load of 3,700 lb. Its cruising radius with a daytime load is 480 miles, and with a night-time load, 850 miles. It is capable of landing at a speed of 47 miles an hour.

The ship has a large cantilever wing with a 99-ft. spread. It is powered with four, 525-hp. Pratt & Whitney motors set in tandem in two nacelles on either side of the wide fuselage. With either pair of motors running, the ship can maintain a cruising speed of 115 miles an hour.

The Consolidated *Commodore*, largest commercial flying boat ever built in America, is the first of a group of twelve which will be placed in service to Buenos Aires. It has an all-metal hull divided into four compartments, one for the pilot, one a lounge accommodating four persons, and the third and fourth, cabins holding eight passengers each. Additional compartments, originally designed for 12 more passengers, have been converted into stowholds for fuel and large shipments of baggage, mail, and fast express. Above the Duralumin hull, a 100 ft. parasol-type wing is supported in struts which also carry the two motors. The plane weighs 9,500 lb. empty. It can lift 8,000 lb. and is capable of maintaining level flight indefinitely on one of its motors. First tests of the plane showed a maximum speed of 130 miles an hour, a cruising speed of 110, and a landing speed of 65 miles an hour.

The *Commodore* is powered with two 575-hp. Pratt & Whitney Hornet motors. Three motors were tried, but the third motor failed to justify itself. The plane is a commercial adaptation of the Navy patrol boat XPY-1.

Propelled by 16 Rockets

Sixteen rockets propel the Opel-Sanders rocket plane, which is a combination of a glider and baby plane. It weighs 250 lb. unloaded and 500 lb. loaded, and has an abruptly abbreviated body which terminates in a magazine containing spaces for 16 rockets, each 18 in. long and 3 in. in diameter. Two steering fins are attached behind the wing which has a spread of about 30 ft. The plane is gotten under way from a 50-ft. running track. It is shot into the air by three rockets weighing 10 lb. each and possessing a lifting or propulsion pressure equal to twice the weight of the machine. These rockets carry an extra heavy load of powder and burn exactly two seconds each, long enough to shoot the carriage, on which the plane rests, down the track, until the plane is catapulted into the air by the explosion of rockets controlled by the pilot. These rockets, which carry the machine through the air, burn for only 25 seconds, during which time they generate a lifting power of 24 kilograms (about 53 pounds) a second. The plane shoots off the running track at a speed variously estimated at 120 to 150 kilometers, or about 75 to 94 miles an hour. Its pace when in the air is controlled by changing the intervals between the firing of the rockets. When the ammunition is exhausted, the plane must glide to earth. Fritz Von Opel, on Sept. 30, made a 1¼-mile flight in 1¼ minutes at an average height of about 50 ft., to demonstrate the uses of the device. He predicts many applications for rockets including their use as brakes to stop a plane, simply by causing them to act in a direction opposite to that of flight.

Max Valier, inventor of the rocket car, is at present working on a machine which derives its propelling force from cold, high-pressure jets of liquid gas. The machine has a long open body with three steel tanks containing gas located beneath the driver's seat. It already has attained a speed of 37 miles an hour. The development of this method of propulsion was undertaken because of the high cost of materials required in powder rocket construction. A rival in these experiments is Professor Oberth, who will make in October his first experiment with a rocket which he hopes to utilize as a mail conveyance between Europe and the United States.

His rocket is described as a 40-ft. double iron tube, coated with copper and containing about 160 lb. of liquid oxygen. Professor Oberth expects the rocket to attain a height of 30 miles, although he regards 45 miles as not beyond reach of possibility.

Fog Difficulties Surmounted

Difficulties in handling of planes in fog are being surmounted by the Daniel Guggenheim fund for the promotion of aeronautics in a series of tests being conducted at Mitchell Field in co-operation with the United States Army. The small Consolidated-Wright biplane, which has been used for the past 11 months by the fund in the tests, recently flew 15 miles and made a perfect landing with the pilot unable to see outside his cockpit. The principal factors in making possible this accomplishment are a new application of the visual radio beacon, the development of an improved instrument for indicating longitudinal and lateral position of a plane in flight, a new directional gyroscope, and a sensitive barometric altimeter, so delicate as to measure its height above the ground within a few feet. In place of the natural horizon, the usual guide of pilots for level flight, invisible in a fog, the pilot uses an artificial horizon in the form of a small instrument which shows him the actual longitudinal or lateral position of his plane with relation to the ground at all times. The visual radio direction finder is used to locate the airport.

* * *

THE California Aircraft Exposition will be held at the exposition building located at Fairfax Ave. and Wilshire Blvd., Los Angeles, Calif., Nov. 9 to 16 inclusive. This exposition is being sponsored and managed by the Aeronautical Chamber of Commerce.

BUSINESS BAROMETER

Advance in security quotations and speculative interest in the stock market are without precedent

By THEODORE H. PRICE
Editor, Commerce and Finance, New York

THE advance in security quotations and the speculative interest in the stock market are without a precedent in the history of the United States or that of any other country. The South Sea Bubble in London, the Mississippi Bubble in Paris, and the canal-building boom in this country were similar in some of their aspects, but there was no telegraph or telephone in those days and it was impossible to get the fires of speculation aflame simultaneously throughout the whole of any one country. There is, however, some resemblance between the canal-building boom and the Coolidge-Hoover boom that now seems to be coming to an end. Both were tacitly sponsored by presidents of the United States. George Washington was the father of canal building in this country. He planned two of the canals which were built to connect the rivers of the Atlantic Seaboard with those of the Mississippi Valley. He served as president of these canals from the surrender at Yorktown in 1783 until he became President in 1789, and his support led to a canal-building movement that was greatly accelerated by the completion of the Erie Canal in 1825. It then became very easy to finance the construction of these artificial waterways, and during the succeeding ten years a great many unnecessary canals were built. But by 1835 the possibilities of railroad transportation commenced to be appreciated. Enthusiasm for the canals began to wane. The resulting depreciation in the value of their securities was responsible for the panic of 1837 which originated in Ohio, and caused distress throughout the country.

These historical observations are prompted by the many inquiries that have come to the writer as a result of the recent decline in the stock market. The writers of these letters seem disposed to censure some anthropomorphic monsters called "They" for the drop in prices, and it is urged that some way to ferret out and punish these malevolent creatures should be found. These proposals are natural, but non-sensical.

In these weekly reviews the inconsistency between the money market and the yield obtainable from securities has been pointed out repeatedly during the last six months. In the circumstances, it is not to be expected that investors will buy stocks or bonds until they can be purchased upon a basis that will yield more than can be obtained by lending their money on call against collateral that is worth at least one and one half times the amount loaned.

This statement is so axiomatic that it is hardly debatable, and we urge that it should be pondered by those who think that some *deus ex machina* is responsible for the recent drop in the stock market. It is true that this inconsistency has existed for a fairly long time and some think it will be perpetuated, but both reason and precedent disclose the folly of any such assumption.

Brokers' loans as reported by the New York Federal Reserve Bank last week set a new high record for the seventh week in succession. During that period the average increase has exceeded $120,000,000 a week. The New York Stock Exchange reports that its members' borrowings rose $668,000,000 during September. Of the time that will be required for the liquidation and re-investment that are pre-requisites of financial normalcy no one can speak.

Therefore, effervescent stock markets are not to be expected, but serious trouble is not anticipated, and the circulation of depressing rumors should be discouraged. In most cases they are likely to be false, and it should always be remembered that "scandal dearly loves a shining mark."

This is said because some rumors of financial trouble and lessened trade activity were circulated last week by those who sought to justify the weakness of the stock market. In so far as can be ascertained, there is no basis for the reports referred to, nor is there any reason to believe that there has been any substantial reduction in trade activity. Quite naturally, the high rates for money have restricted building, but this restriction has been frequently alluded to in this review, and it should cause no apprehension.

The output of new automobiles is also showing a decline and the demand for steel and iron is a little less eager than it was at this time a year ago, but none of these changes are significant, and it is absurd to maintain that American prosperity is conditioned upon a constant and unvarying gain in its business or industrial output.

The truth is that the buying power of our wage earners and our agricultural workers is about as high as it ever was in the history of the country, and that the activity of our trade is dependent upon whether those who are able to buy feel disposed to purchase. It is possible that an era of economy may succeed the period of extravagance through which we have just passed. In that case we may have lower prices, and duller trade for a time, but if we get back to the orthodoxy which teaches that "economy is wealth" we shall be better off in the long run, and our prosperity will rest upon a sounder basis although we may not feel the foolish exhilaration which rapid spending seems to induce.

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From this page the reader will get a quick picture of current business and industry. The boxed material below is a summary of the letters from regional correspondents of the American Machinist, published in full on the opposite page.

MACHINERY and machine-tool market interest during the past week was centered in Cleveland at the National Machine Tool Builders' Show. Other cities reported but little business, indicating practically an exodus of machinery buyers for the week No change in deliveries, prices, or the class of tools desired was indicated. Used tools are in demand when comparatively modern ones in good condition are obtainable.

RAILROADS were the principal purchasers during the week. New York reported a considerable volume of railway business in locomotives and rolling stock, the purchase of 100 locomotives costing $9,000,000 by the Pennsylvania Railroad heading the list. Philadelphia also reported some railway sales and a good week otherwise. Cincinnati and Chicago business has slowed up, largely because of the Show, but Detroit business has fallen off as a result of changes in engine design. Milwaukee conditions are spotty, with a shortage of labor and production at the peak. New England reports conditions about as they were.

SOUTHERN DISTRICT business is quiet, but inquiries indicate good business later. Buffalo conditions are improving. The last quarter of the year is expected to be as good as the first two in that district. Cleveland orders received a decided impetus from the Show, and the outlook for the remainder of the year is considered good.

THE INDUSTRIAL REVIEW

Weekly progress of the machinery and machine-tool business

THE following reports, gathered from the various machinery and machine-tool centers of the country, indicate the trend of business in these industries and what may be expected from the future:

CLEVELAND

Sales of machinery and machine tools which have been practically at a standstill during the last two weeks of September have received real impetus during the Machine Tool Show. Prospective buyers who postponed action on orders until viewing the exhibits were placing orders daily during the Show. Sales are principally for one and two pieces. One sales agent had 50 inquiries previous to the Show and he expects to close on a large majority in the near future. Immediate resumption of active buying is expected. The outlook for October and the last quarter of the year, according to the consensus among machinery men, is highly favorable.

Exhibitors at the Cleveland Show were enthusiastic in their praise of the magnitude, orderliness and the expected financial success of the exposition. Some hope was expressed that future shows would include an exhibit by the woodworking machinery manufacturers.

PHILADELPHIA

While the business in the machinery and machine-tool lines in the Philadelphia market has maintained a fairly good volume during the last month, the briskness which characterized the trade during the earlier fall has not been so apparent.

Some shop equipment was purchased by the Pennsylvania Railroad and the Chicago & Northwestern Railroad during the last two weeks. There was some industrial equipment disposed of in the Middle West and the aircraft industry made some purchases in this market. Sales included compressors, borers, planers, shapers, and some milling machines.

The falling off in sales was attributed by some to the Show in Cleveland. Those who have been anticipating purchases may be awaiting the result of their visits to the show, dealers believe. A fairly sizable list of inquiries have come from general industrial lines doing business in this territory. On the whole, those inquiries bear a hopeful tone, and the closing of some substantial sales is looked for at an early date.

BUFFALO

Business in the machine-tool trade has shown a marked improvement during the last few days. There is every reason to believe that October is to be classed as one of the very good months of the year, unless there is an unexpected falling off. In fact, it is altogether likely that the last quarter of the year will compare with the first and second quarters.

Construction activities have increased in Buffalo with the beginning of the erection of the new City Hall and the New York state office building at Niagara Square, running into many millions of dollars. This has not yet materially affected the demand for contractors' supplies although it may do so as time goes on. Both of the public works jobs mentioned will continue for some time and the City Hall represents one of the biggest undertakings in Buffalo.

DETROIT

With automobile manufacturers decreasing their production and unemployment increasing almost daily, the general market for machinery and machine tools here is very poor. Last week, most of the dealers and a great many prospective buyers attended the Show at Cleveland and the amount of business closed here was negligible.

It is generally conceded that the automobile business is likely to remain at its present low level for the balance of the year. There is a strong probability that it will improve after the first of the year, but not much before that. The big automotive producers are engaged in the work of tooling up for the manufacture of eight-cylinder cars, and this fact, perhaps more than anything else, has brought about the depression. Few cars are being sold, little or no machinery is being bought, and employees are being laid off in increasingly large numbers.

CHICAGO

Comparatively little activity in the machine-tool market has developed during the last week, owing to the fact that the Tool Builders' Exposition at Cleveland has drawn from their offices and plants both buyers and sellers of machinery equipment in large numbers. At this writing, only a few of the selling agents and district managers who attended the Show have returned, but those who are back express themselves as most optimistic regarding the outlook as a result of the Exposition. As noted a week ago, there has been a falling off in both sales and inquiries for a period extending back over two weeks, and, while much is expected from the getting together of tool builders and their prospective customers, it is not believed there will be any marked improvement in the situation until October is well advanced. Railroad buying is confined for the greater part to actual requirements, much of it being for replacement purposes. The Pullman Co. still is a factor in the market, and has added several items to its lists. Demand for used tools is steadily improving, and good prices are being realized for units in first-class shape. So far as can be gathered, the total volume of September business will fall somewhat short of that of August.

NEW YORK

Railroad orders for rolling stock were the only events of importance in New York during the past week. The city was deserted by machinery and machine-tool buyers and dealers alike. From every quarter came reports of record attendance at the Machine Tool Show. Secretaries maintaining businesses during the absence of their superiors reported only small orders for maintenance and replacement, with only one sale of any size reported, that of a gear-milling machine. Inquiries and orders, which for the past few weeks have been listless, are expected to pick up rapidly now.

The Pennsylvania Railroad ordered 100 mountain-type, fast freight locomotives, to cost in the neighborhood of $9,000,000. The Great Northern Railway bought four, 3,000-hp. electric locomotives, costing $1,000,000, for use through the eight-mile Cascade tunnel, and 10 others for other use. The Chicago, Burlington & Quincy Railroad has ordered 500 automobile, 600 flat, 800 hopper, 10 baggage, 14 suburban cars, and 10 gasoline-electric cars, and 8 Mikado and 5 large traffic locomotives. The Boston & Maine has purchased 1,000 box cars and 500 flat cars, and the Norfolk & Western has ordered 200 steel cars. Meanwhile, the Chesapeake & Ohio ordered 53,480 tons of steel rails, and the Pere Marquette ordered 20,300 tons.

There were no price changes or delivery changes indicated during the week. Used tool demand continues.

SOUTHERN DISTRICT

Though the inquiry continues fairly good for fall and early winter requirements, the machinery and machine-tool business is rather quiet in the southern territory. However, the volume of trade is fully as large as it was at this time last season, and there are but few dealers who do not believe that during the latter part of this year sales will be considerably better than they were for the corresponding period in either 1927 or 1928.

In the woodworking field there has recently been a tendency towards improvement, and sales are better now than they have been in several months, with the inquiry exceptionally good, especially from the furniture factories in the Carolina, East Tennessee and Georgia district. There is also more buying of woodworking machinery from other branches of the trade in all of the southeastern states.

The textile industry still is placing some good orders for equipment for new mills that are going up, but this business is quite a bit less active than it was during the summer period. The outlook is exceptionally good for the first half of 1930. Some orders for heavier equipment also are reported from railroads for new shop projects under way, but this trade also is less active than it was during the summer months.

NEW ENGLAND

Little change has been noted in the New England machinery and machine-tool situation. Business was relatively quiet, although prospects for the future are bright. Obviously, the interest of the industry centered at the Cleveland Show. Inquiry from the automotive and the aeronautical fields is promising, and at least one additional New England railroad plans a program of active buying. The Bangor & Aroostook plans expenditures amounting to $1,500,000. Included are road-building equipment and machine tools.

Indices of September business as a whole registered slight declines. Some industries showed a continuation of unusual activity, while others, notably the textile, shoe, and paper industries, reported curtailments. The month of September, as far as the machine-tool industry in New England is concerned, may best be described as spotty, but with the total sales volume at a level well above September, 1928. It is noteworthy that used tool dealers, as a whole, had a better month than in August. Now that the Cleveland Show is about over, a revival of stimulated buying is in order. Just now there is a good volume of machine-tool business hanging fire on which action should be terminated shortly.

CINCINNATI

Machine-tool manufacturers in the Cincinnati district report generally that there has been a falling off in sales in the past week as compared to the previous week, the lull being attributed to the fact that

prospective purchasers have postponed buying until after the close of the National Machine Tool Builders' Exposition. Manufacturing activity has not been affected, however, as there is a sufficient amount of business booked to keep the plants busy for some time.

Selling agents report that, because of the retarding influence of Show, their sales have also dropped considerably in the past week. Following the Exposition the market is expected to liven up in the local and adjacent territory, with even better demand than before.

The week's orders were well scattered geographically and well diversified in the matters of sizes and types. The great majority of the purchases were for single tools, but here and there was an order for two or three pieces of equipment.

Among the week's inquiries were two small lists of requirements from the Navy, and several inquiries with regard to single tools. The general inquiries were not as numerous as in the previous week, the majority of them being from small plants.

Manufacturers here forecast that in the next week or two the market will liven up again and sales will return to a good level.

MILWAUKEE

Orders fell off slightly during September according to some accounts, while a few report that there was no recession. Whatever the disparity there may have been between September and August figures, it is attributed without exception to the show at Cleveland, and there has been no appreciable shrinkage of the volume of inquiries. Many more deals are pending at the beginning of October than at the start of either August or September, and no improvement is noted in the general delivery situation.

All of the metal-working industries continue production at or near capacity and the shortage of experienced machinists still continues. Agricultural implement manufacturers have had a profitable season and are in the market for considerable lists of machinery for next year's production, which they predict will be as great for most of the plants as it was during this year, while local plants have planned to some extent for considerable expansion.

Automobile production in Wisconsin factories continues at low ebb, but there is no lack of inquiries from them, and makers of automotive parts continue production at peak. Although manufacturers of woodworking machinery continue to complain of slackness, business for them has revived in spots because of the adding of new lines in cabinet and furniture shops.

Business Items

Construction will begin at once on a Pacific Coast branch of the Fokker Airplane Company to cost approximately $300,000, according to a recent announcement by officials of the company. The plant will be located on the 33-acre tract adjacent to the Western Air Terminal, Alhambra, Calif. According to the present plans, 500 men will be employed at the plant during the first few months of operation and this number is expected to be increased in a short time.

The Hughes Tool Co., Houston, Tex., has let a contract for the erection of a structural steel shop building.

The Package Machinery Co., Springfield, Mass., and the Baker Perkins Co., Inc., Saginaw, Mich., have secured substantial interests in the National Bread-Wrapping Machine Co., Nashua, N. H., which is to be reorganized and located in Springfield. A merger of the three companies is thus effected. Officials of the National company have been elected as follows: President, R. E. Baker, Baker Perkins Co., Inc.; vice-president, R. L. Putnam, Package Machinery Co.; secretary and treasurer, Roe S. Clark, Package Machinery Co.; and managing director, Henry A. Sevigne, National Bread-Wrapping Machine Co. Directors include the above and R. W. McKenzie, Carl Pletscher, Paul Langhammer and E. Lovel Smith.

Acquisition of a controlling interest in the Joseph Kreutzer Corporation, Los Angeles, Calif., has been announced by Howard Throckmorton, president of the Valley Portland Cement Co. Joseph Kreutzer, former president, will act as the chairman of the new board of directors. Other officers include E. Milton Jones, vice-president; C. W. Williamson, secretary; Nathan Newby and J. C. Howard, directors.

The Boykin Machinery & Supply Co., 1701 Laurel St., Beaumont, Tex., has been purchased by the International Derrick & Equipment Co., also of Houston. The new owners have completed the reorganization of the Boykin concern, and will henceforth operate the plant as a subsidiary. Harry M. Runkle, Columbus, Ohio, is president, and B. Boykin, Jr., 2029 Broadway, Beaumont, Tex., becomes vice-president.

The new factory of the Axelson Aircraft Engine Co., Los Angeles, Calif., will start production about Oct. 15, company officials have announced. This plant contains more than 25,000 sq.ft. of floor space, will employ 200 workmen, and has been designed for an initial production of three to four engines daily.

Completion of the fourth unit of the Bach Aircraft factory, Los Angeles Metropolitan Airport, Van Nuys, Calif., has been announced by B. L. Graves, president. This plant has facilities for manufacturing planes with five different engine combinations.

The Central Alloy Steel Corporation, Massillon, Ohio, has authorized the expenditure of more than $600,000 for important improvements at both the Massillon and Canton plants, according to a recent announcement by Chairman F. J. Griffiths.

The Texas Machine & Foundry Co., 636 Rigsby St., San Antonio, Tex., awarded contracts recently for the construction of two machine shops which will be operated in conjunction with the company's plant at San Antonio.

W. P. Christian, Inc., was organized and incorporated at Greensboro, N. C., recently with a capital stock of $100,000, the incorporators named including W. P. Christian, 718 Percy St., that city, and associates.

Incorporation of the Nu-Way Casting Co., Council Bluffs, Iowa, has been recorded. N. F. Davies, Grand Island, Neb., is president; A. W. Collins, Omaha, vice-president and secretary; Harry E. Wells, Stapleton, Neb., treasurer, and other incorporators are W. A. Davies and Elmer C. Loy.

The Yale & Towne Manufacturing Co., Stamford, Conn., has negotiated for the purchase of the H. & T. Vaughn Co., Ltd., Willenhall, Eng. Stockholders of the latter company meet Oct. 10 to ratify the proposed contract.

The Walworth Co., Boston, Mass., will organize a subsidiary company to handle the Westcott Valve Co., East St. Louis, Ill., recently purchased, according to an announcement by the board of directors.

The American Cast Iron Pipe Co., 2930 N. 16th St., Birmingham, Ala., operating a foundry and machine shop plant recently obtained a permit for the construction of a $50,000 addition to the plant.

The Aircraft Stream Line Co., Cincinnati, will open a plant on the grounds of the City Airport. It will be a subsidiary of the Hill Auto Metal Body Works, 822 Reedy St., which will remain at the present location.

The Allied Die Casting Corporation is building a four-story plant in Long Island City, N. Y., which will contain 75,000 sq.ft. of floor space. The plant will be occupied Nov. 15.

The Kari-Keen Manufacturing Co., West Seventh and Division Sts., Sioux City, Iowa, has let contract for an addition, 88x268 ft., costing $50,000, which will be completed late this fall.

The Paasche Airbrush Co., 1909 to 1923 Diversey Parkway, Chicago, has moved the New York sales and service branch to 103 Lafayette St. L. J. Dagon continues as branch manager.

The Hardwicke-Etter Co., Sherman, Tex., will start the construction of a new plant at that city for the manufacture of machinery and parts.

The Samson-United Corporation, Rochester, N. Y., has been formed to absorb the business of the Samson Cutlery Co. of that city.

The Hendey Machine Co., Torrington, Conn., is erecting an 80x410 ft. addition, fireproof, one story in height.

The Starr Hardware Corporation, 405 Monroe St., Hoboken, N. J., has opened a warehouse at 57 Warren St., New York City.

The Rundle Manufacturing Co., Milwaukee, have begun work on a material storage yard to include conveyors and other equipment.

The American Chain Co., Inc., and associated companies have moved their Chicago offices to Room 1765, Chicago Daily News Building.

The Brent Pipe Co., Los Angeles, Calif., has started the construction of a $100,000 branch plant at Dallas, Texas.

The Gardner-Denver Co., has moved its New York branch office from 30 Church St. to 147 Varick Street.

Personals

MAURICE G. STEELE, for the past four years development engineer for the Hart & Hutchinson Co., New Britain, Conn., has taken a position as manager of the Rome Radiation Co., Rome, N. Y., and will be in charge of research, manufacturing, and development. Mr. Steele was formerly connected with the Hartford Automatic Refrigerating Co., Hartford, Conn., for 16 years, and was at one time assistant chief engineer and sales manager.

DR. GEORGE B. WATERHOUSE, professor of metallurgy at the Massachusetts Institute of Technology, will head the Iron Alloys committee of the Engineering Foundation, according to a recent announcement. With the co-operation of industries, engineering societies, universities, and the U. S. Government, the committee will inaugurate a program of co-operative research on alloy irons and alloy steels.

PROF. W. TRINKS, department of mechanical engineering, Carnegie Institute of Technology, will direct a two-year research fellowship at the Institute sponsored by the A.S.M.E. The fellowship is established to investigate the forces in rolling iron and steel under different conditions, the proper roll and neck sizes, and the saving in power consumption by better lubrications of sliding bearings and by the substitution of anti-friction bearings instead of brass bearings.

DR. RICHARD MOLDENKE, consultant in foundry operations and nationally known metallurgical engineer, will address the Fall meeting of the Philadelphia Foundrymen's Association on Oct. 9. Dr. Moldenke will speak on "The Evolution of the Foundry," and will trace the development of present-day production principles from their inception.

C. E. SMITH, vice-president of the New York, New Haven & Hartford Railroad, and assistant to the president in matters pertaining to engineering, has been appointed head of the department of stores and purchases to succeed the late Nathaniel M. Rice.

RALPH MODJESKI, engineer, was recently awarded the John Fritz Medal by a board composed of 16 past presidents of the four national engineering societies. DEXTER S. KIMBALL, a director of the McGraw-Hill Co., is a member of the board which made the award.

PAUL G. WELLENKAMP, formerly shop superintendent with the Fairchild Engine Corporation, Farmingdale, L. I., is now assistant production engineer of the Wright Aeronautical Corporation, Paterson, N. J. He will have charge of tooling.

A. D. EVANS, formerly in charge of development work for the American Sheet & Tin Plate Co., Shenango Works, Newcastle, Pa., has become affiliated with the Wean Engineering Co., Inc., Warren, Ohio, as chief engineer in charge of development work and all engineering in connection with sheet and tin-plate equipment.

WALTER KNAPP has been appointed executive engineer of the De Walt Products Corporation, Leola, Pa. Mr. Knapp is a mechanical engineer graduated from Cornell and has had many years experience in plant engineering in all of its phases.

NEIL C. HURLEY was elected a member of the Independent Pneumatic Tool Co., Chicago, at a recent meeting of the board of directors. RAYMOND J. HURLEY was elected a director at the same time.

FRANK CARTER, formerly United States government metallurgical inspector has been placed in charge of the metallurgical department of the James H. Knapp Co., Los Angeles.

WILLIAM C. CUSHING, engineer of standards of the Pennsylvania Railroad, has been elected to honorary membership in the American Railway Engineering Association.

H. W. STREEBY has been appointed field service engineer for the southeastern district by the Lyon Metal Products, Inc., Montgomery St., Aurora, Illinois.

Obituaries

H. COLE ESTEP, vice-president of the Penton Publishing Co., Cleveland, died suddenly of heart failure on Sept. 30. He had been identified with various Penton publications during the past 21 years, serving as engineering editor on *Iron Trade Review*, and later of *Marine Review*, and was closely identified with the direction and development of *Daily Metal Trade*. He was also president of the Johnson Publishing Co., Cleveland, publisher of *Machine Design*. He was secretary of the Foundry Equipment Manufacturers' Association, a member of the American Iron and Steel Institute, the American Foundrymen's Association, and the A.S.M.E.

W. W. DRINKER, chief engineer of the port of New York Authority, died Sept. 16 at his home in Ridgewood, N. J., of heart disease. He had been associated with the Delaware, Lackawanna & Western, the Delaware & Hudson, and the Erie Railroad for the past 30 years. He was 60 years of age.

THOMAS D. BOWEN, vice-president of the American Telephone and Telegraph Co., who had been with that organization for 35 years, died recently in New York on his sixty-second birthday. Mr. Bowen was promoted to a vice-presidency about seven years ago.

DAVID CLARK WHEELER, founder and president of the Acme Shear Co., Bridgeport, Conn., died Sept. 29 at his home 470 Brooklawn Ave., that city. Mr. Wheeler was 74 years old. When a young man, with his brother Dwight C. he founded the Acme Shear Co. Mr. Wheeler was treasurer of the company for 46 years and president and treasurer at the time of his death.

HOMAR L. JOHNSON, 30, assistant secretary of the A.I.M.E., was killed in an autobobile accident near Fairfax, Va., on Sept. 17. He was assistant editor of *Engineering & Mining Journal*, New York, a McGraw-Hill publication, until three months ago when he resigned to become affiliated with the Mining and Metallurgical Institute.

WALTER C. WHITE, 53, president of the White Motor Co. and a leading automotive manufacturer, died on Sept. 29 in Cleveland. Mr. White was fatally injured in an automobile crash on Sept. 28.

OWEN S. WRIGHT, 63, for the past 23 years local purchasing agent at the Indianapolis plant of the National Malleable & Steel Castings Co., died at his home following an illness.

CAPT. W. MCL. S. JACKSON, automotive engineer and inventor of New York City, died in Philadelphia on Sept. 10. He was 49 years old.

WILLIAM C. UPSON, 70, an official of the Winchester Repeating Arms Co., New Haven, Conn., died at his home in that city recently.

GEORGE C. HILL, secretary of the Reese Buttonhole Machine Co., Boston, died on Sept. 29, in that city.

CHARLES E. WALSH, inventor, died at his home in Cleveland recently.

Forthcoming Meetings

GRAY IRON INSTITUTE—Annual meeting, Hotel Cleveland, Cleveland, Ohio, Wednesday, Oct. 16. Information may be obtained from Arthur J. Tuscany, manager, Terminal Tower Building, Cleveland.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Regional meeting, Akron, Ohio, Oct. 21 to 23. Calvin W. Rice, 29 W. 39th St., is secretary.

SOCIETY OF INDUSTRIAL ENGINEERS. Sixteenth national convention at Hotel Statler, Cleveland, October 23 to 25. Requests for programs should be sent to S.I.E. national office, 205 West Wacker Drive, Chicago.

AMERICAN GEAR MANUFACTURERS' ASSOCIATION. Semi-annual fall meeting at the Benjamin Franklin Hotel, Philadelphia, October 24 to 26. T. W. Owen, secretary, 3608 Euclid Ave., Cleveland.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS — Annual meeting, New York, Dec. 2 to 6. Headquarters will be at 29 W. 39th St., New York City. Calvin W. Rice is secretary.

THE WEEKLY PRICE GUIDE . . .

Rise and Fall of the Market

STRUCTURALS and railroad steel form the greater part of present volume of demand, offsetting in large measure the decline in automotive requirements. There is a steady market for pipe, discounts having been increased in New York and Chicago. The seasonally heavy buying of bolts and nuts is in contrast with light orders for rivets. Prices for scrap iron, steel and brass continue weak. Mixed paints are up about 25c. per gal. due to sharp advances in linseed oil. Drought caused scarcity of linseed here and abroad, with the result that prices in Argentine are highest in eighty years.

(All prices as of Oct. 4, 1929)

IRON AND STEEL

PIG IRON—Per gross ton, f.o.b:

CINCINNATI	
No. 2 Southern (silicon 1.75@2.25)	$17.69@$18.19
Northern Basic	19.90
Southern Ohio No. 2	19.90
NEW YORK—Tidewater Delivery	
No. 2 Southern (silicon 1.75@2.25)	19.50
BIRMINGHAM	
No. 2 Foundry (silicon 1.75@2.25)	14.00@14.50
PHILADELPHIA	
Eastern Pa., No. 2x (silicon 2.25@2.75)	21.26@21.76
Virginia No. 2	24.04
Basic	19.75@20.25
CHICAGO	
No. 2 Foundry, local (silicon 1.75@2.25)	20.00
No. 2 Foundry, Southern (silicon 1.75@2.25)	20.01
PITTSBURGH, including freight charge ($1.76) from Valley:	
No. 2 Foundry	20.26
Basic	20.26
Bessemer	20.76

IRON MACHINERY CASTINGS—Cost in cents per lb. of 100 flywheels, 6-in. face x 24-in. dia., hub not cored, good quality gray iron, weight 275 lb:

Detroit	4.50
Cleveland	5.00
Cincinnati	4.50
New York	5.25
Chicago	4.50@4.75

SHEETS—Quotations are in cents per pound in various cities from warehouse; also the mill base in large lots:

Blue Annealed*	Pittsburgh Mill Base	Chicago	Cleveland	New York
No. 10	2.10@2.20	3.35	3.30	3.90†
No. 12	2.15@2.25	3.45	3.35	3.95†
No. 14	2.25@2.35	3.55	3.45	4.00†
No. 16	2.35@2.45	3.65	3.55	4.10†
Black				
Nos. 18 to 20	2.65	3.85	3.70	3.80
No. 22	2.80	4.00	3.85	3.95
No. 24	2.85	4.05	3.90	4.00
No. 26	2.95	4.15	4.00	4.10
No. 28	3.10	4.75	4.15	4.25
Galvanized				
No. 10	2.80@2.90	4.20	4.05	4.05
Nos. 12 to 14	2.90@3.00	4.30	4.15	4.15
No. 16	3.00@3.10	4.40	4.25	4.25
No. 18	3.15@3.25	4.55	4.40	4.40
No. 20	3.30@3.40	4.70	4.60	4.55
No. 22	3.35@3.45	4.75	4.65	4.60
No. 24	3.50@3.60	4.90	4.75	4.75
No. 26	3.75@3.85	5.15	5.00	5.00
No. 28	4.00@4.10	5.40	5.25	5.25

*Light plates. †Up to 3,999 lb.

WELDED STEEL PIPE—Warehouse discounts are as follows:

	New York		Cleveland		Chicago	
	Black	Galv.	Black	Galv.	Black	Galv.
1 to 3 in. butt	53.74%	41.2%	55.5%	43.5%	55.5%	42.5%
3½ to 6 in. lap	50.32%	37.78%	53.5%	40.5%	51.6%	39.0%

WROUGHT-STEEL PIPE LIST

Size, Inches	List Price per Foot	Diameter in Inches External	Diameter in Inches Internal	Thickness Inches
⅛	$0.17	1.315	1.049	.133
¼	.23	1.66	1.38	.14
⅜	.27½	1.9	1.61	.145
½	.37	2.375	2.067	.154
⅝	.58½	2.875	2.469	.203
¾	.76½	3.5	3.068	.216
⅞	.92	4.0	3.548	.226
1	1.09	4.5	4.026	.237
1¼	1.27	5.0	4.506	.247
1½	1.48	5.563	5.047	.258
2	1.92	6.625	6.065	.28

SEAMLESS STEEL TUBING—Following net prices are for seamless mechanical tubing, cold drawn, round, .10 to .30 carbon, at New York warehouse in lots of less than 100 ft. or 100 lb:

Thickness Decimal Fractions	B.w.g. and	Outside Diameter in Inches ½	⅝	¾	⅞	1	1¼	1½
		Price per Foot						
.035″	20	$0.15	$0.16	$0.17	$0.18	$0.19	$0.21	$0.23
.049″	18	.17	.18	.19	.20	.21	.23	.25
.065″	16	.19	.20	.21	.22	.23	.25	.27
.083″	14	.20	.22	.23	.24	.25	.27	.29
.095″	13	.21	.23	.25	.26	.27	.29	.31
.109″	12	.22	.24	.26	.27	.28	.30	.32
.120″ or .125″	11	.23	.25	.27	.28	.29	.31	.33
.134″	10	.24	.26	.28	.29	.30	.32	.34

MISCELLANEOUS—Warehouse base prices in cents per lb:

	New York	Cleveland	Chicago
Spring steel, light*	4.50	4.65	4.65
Spring steel, heavier	4.00	4.00	4.00
Coppered Bessemer rods	6.05	6.00	6.20
Hoop steel	4.25†	4.00	4.15
Cold rolled strip steel	6.25	6.00	6.10
Floor plates	5.10†	5.30	5.00
Cold drawn, round or hexagon‡	3.60	3.65	3.60
Cold drawn, flat or square‡	4.10	4.15	4.10
Structural shapes	3.30†	3.00	3.10
Soft steel bars	3.30†	3.00	3.00
Soft steel bar shapes	3.30†	3.00	3.00
Soft steel bands	3.75†	3.65	3.65
Tank plates	3.30†	3.00	3.10
Bar iron (2.75 at mill)	3.25	3.00	3.00
Drill rod (from list)	60%	55%	50%

*Flat, 3/16-in. thick. †Up to 3,999 lb., ordered and released for shipment at one time. ‡Cold finished steel, shafting and screw stock.

Electric welding wire at New York warehouse— 5/32, 8.35c. per lb.; ¼, 7.85c. per lb.; 5/16 to ½, 7.35c. per lb.

METALS

Warehouse Prices in Cents Per Pound for Small Lots:

Copper, electrolytic, New York			19.25
Tin, Straits, pigs, New York			47.50@48.50
Lead, pigs, E. St. Louis	6.70	New York	7.62½@8.12½
Zinc, slabs, E. St. Louis	6.80	New York	7.75@8.25

	New York	Cleveland	Chicago
Antimony, slabs	11.00@11.50	11.75	14.50
Copper sheets, base	27.75	27.75	27.75
Copper wire, mill, base	20.12½	20.12½	20.12½
Copper, drawn, round, base	26.25	26.25	26.25
Copper tubing, base	29.25	29.25	29.25
Brass sheets, high, base	23.25	23.25	23.25
Brass tubing, high, base	28.25	28.25	28.25
Brass rods, high, base	21.25	21.25	21.25
Brass wire, high, base	23.75	23.75	23.75

SHOP MATERIALS AND SUPPLIES

METALS—Continued

	New York	Cleveland	Chicago
Aluminum ingots, 99%.....	25@26	24.30	24.30
Zinc sheets (casks).....	10.50@11.00	11.70	10.11
Solder (½ and ½).....	33.00	32.75	31@34
Babbitt metal, delivered in case lots, New York, cents per lb:			
Genuine, highest grade.....			64.00
Commercial genuine, intermediate grade.....			48.00
Anti-friction metal, general service.....			31.50
No. 4 babbitt.....			12.00

NICKEL AND MONEL METAL—Price in cents per lb., base, f.o.b. Huntington, W. Va:

	Nickel	Monel Metal
Sheets, full finished.....	52.00	42.00
Sheets, cold rolled.....	60.00	50.00
Strip, cold rolled.....	55.00	45.00
Rods, hot rolled.....	45.00	35.00
Rods, cold drawn.....	53.00	40.00
Tubing	75.00*	90.00†
Angles, not rolled.....	50.00	40.00
Plates.....	52.00	42.00

*Beamless. †Welded.

OLD METALS—Dealers' purchasing prices in cents per pound, f.o.b. cars, depending on quantity offered for sale:

	New York	Cleveland	Chicago
Crucible copper.....	15.50 @15.75	13.50	13.00 @14.00
Copper, heavy, and wire..	14.75 @15.75	13.00	12.00 @13.00
Copper, light, and bottoms	13.00 @13.50	12.50	11.00 @12.00
Heavy lead.....	5.62½@ 5.87½	6.25	4.75 @ 5.25
Tea lead.....	4.00 @ 4.25	4.25	3.75 @ 4.25
Brass, heavy, yellow.....	8.50 @ 9.00	8.00	8.00 @ 8.50
Brass, heavy, red.....	12.00 @12.50	12.50	11.75 @12.25
Brass, light.....	7.00 @ 7.50	7.50	7.00 @ 7.50
No. 1 yellow rod turnings.	9.75 @10.25	9.00	9.00 @ 9.50
Zinc.....	3.25 @ 3.50	3.25	3.00 @ 3.25

TIN PLATES—Charcoal—Bright—Per box:

	New York	Cleveland	Chicago
"AAA" Grade:			
IC, 14x20.....	$12.10	$11.95	$11.50
"A" Grade:			
IC, 14x20.....	9.70	9.90	9.50
Coke Plates—Primes—Per box:			
100-lb., 14x20.....	6.45	6.10	7.00
Terne Plates—8-lb. Coating—Small lots—Per box:			
IC, 14x20.....	7.75@8.00	7.00	7.50

MISCELLANEOUS

	New York	Cleveland	Chicago
Cotton waste, white, per lb.*	$0.10@0.13½	$0.16	$0.15
Cotton waste, colored, per lb.*	.09@ .13	.12	.12
Wiping cloths, washed white, per lb.†.....	.16	38.00 per M	.16
Sal soda, per lb.....	.02½	.02	.02
Roll sulphur, per lb.....	.027	.03½	.04
Linseed oil, raw, in 1 to 4 bbl. lots, per lb.....	.167	.174	.173
Cutting oil, about 25% lard, in 5 gal. cans, per gal.....	.75	.60	.65
Machine oil, medium-bodied (55 gal. steel bbl.) per gal..	.33	.36	.24
Belting — Present discounts from list in fair quantities (½ doz. rolls) for leather or rubber:			
Leather—List price, 24c. per lin. ft., per inch of width, for single ply:			
Medium grade.....	30–10%	30–10%	35%
Med. grade, heavy wgt...	30%	30– 5%	30%
Rubber transmission, 6-in., 6 ply, $1.83 per lin.ft:			
First grade.....	50%	50–10%	50%
Second grade.....	60%	60– 5%	50–10%

*All waste in bale lots. †100-lb. bales.

Comparative Warehouse Prices

New York	Unit	Current Price	Four Weeks Ago	One Year Ago
Soft steel bars.....	per lb..	$0.033	$0.033	$0.0325
Cold drawn shafting...	per lb..	.036	.036	.034
Brass rods.....	per lb..	.2125	.2125	.175
Solder (½ and ½).....	per lb..	.33	.3325	.34
Cotton waste, white...	per lb..	.10@.13½	.10@.13½	.10@.13½
Disks, aluminum oxide mineral, cloth, No. 1, 6-in. dia.....	per 100.	3.60	3.60	3.05
Lard cutting oil.....	per gal.	.75	.75	.65
Machine oil.....	per gal.	.33	.33	.30
Belting, leather, medium.....	off list..	30–10%	30–10%	30–10%
Machine bolts, up to 1x30 in., full kegs...	off list..	50-10%*	50–10%*	50%*

*List prices as of April 1, 1927.

MISCELLANEOUS—Continued

	New York	Cleveland	Chicago
Abrasive materials — Standard grade, in sheets 9x11 in., No. 1, per ream of 480 sheets:			
Flint paper.....	$4.86	$4.29	$4.29
Emery cloth.....	22.93	20.97	20.97
Disks, aluminum oxide mineral, 6 in. dia., No. 1, per 100:			
Paper.....	2.08	2.04	2.04
Cloth.....	3.60	3.59	3.59
Fire clay, per 100 lb. bag.....	1.00	.75	.75
Coke, prompt furnace, per net ton.....	Connellsville, 2.65@2.75		
Coke, prompt foundry, per net ton.....	Connellsville, 3.75@4.85		
White lead, dry or in oil...	100 lb. kegs....	New York, 13.75	
Red lead, dry.....	100 lb. kegs....	New York, 13.75	
Red lead, in oil.....	100 lb. kegs....	New York, 15.25	

SHOP SUPPLIES

Discounts from new list dated Apr. 1, 1927, applying on immediate deliveries from warehouse stocks in New York and vicinity:

Machine bolts:	
Up to ¾-in. x 6-in., full kegs, list less.....	60%
Larger, up to 1 x 30-in., full kegs, list less.....	50–10%
Less than full kegs or case lots, add to list.....	10%
Fitting-up bolts: list less.....	45%
Lag screws:	
Up to ½-in. x 6-in., list less.....	60%
Larger, list less.....	50–10%
Less than full keg or case lots, add to list.....	10%
Rivets:	
Structural, round head, full kegs, net.....	$4.50
Structural, round head, broken kegs, net.....	6.00
Tank, $\frac{7}{16}$-in. dia. and smaller, list less.....	60%
Nuts:	
Hot pressed, square or hexagonal, blank or tapped:	
Full kegs up to 1-in., incl., list less.....	60%
Larger, up to 3-in., list less.....	40–10%
Less than keg or case lots, add to list.....	10%
Washers:	
Wrought, full kegs, per 100 lb., list less.....	$4.00
Wrought, broken kegs, per 100 lb., list less.....	2.00
Turnbuckles:	
With stub ends, list less.....	20%
Without stub ends, list less.....	50%
Chain:	
Proof coil, base, per 100 lb., net.....	$7.10
Cast iron welding flux, per lb., net.....	.40
Brazing flux, per lb., net.....	.80

MACHINE REQUIREMENTS AND INDUSTRIAL CONSTRUCTION

Equipment Wanted

D. C., Washington—Bureau of Supplies & Accounts, Navy Dpt.—will receive bids until Oct. 15 for engine lathes, metal cutter, foot operated gap shear, milling die sinking machine, bench jointers, band and bench saws, also until Oct. 22 for engine lathes, precision lathes, tool and cutter, grinding machine, cutter, reamer and surface grinders, motor driven, metal cutting hacksaws, and vertical turret lathes.

Mass., Gleasondale—Standard Brake Lining Co.—punch press, spot welder, high speed bench drill and small circular angle bending machine.

Mich., Detroit—Inter City Trucking Service, 432 St. Aubin Ave.—garage and machine shop equipment for servicing trucks for proposed 1 story, 125 x 295 ft. truck terminal. Estimated cost $150,000.

Mich., Detroit—F. L. Jacobs Co., 6901 East Lafayette Ave. (tubing manufacturers)—drilling machine and equipment.

Mich., Pontiac — Thompson Aeronautical Corp., Union Trust Bldg., Detroit—repair shop equipment for servicing and testing aircraft for proposed 1 story, 125 x 150 ft. airport development. Estimated cost $100,000.

Minn., Minneapolis—City, F. S. Gram, Purch. Agt.—will receive new bids until Oct. 17 for lathe. Former bids rejected.

O., Portsmouth—G. Schirman, 5th St.—machinery and equipment including automatic machine, drill press, grinder and air compressor for new garage.

Tex., San Antonio—U. S. Government, c/o C. H. Caldwell, Duncan Field, machinery and equipment for proposed mcahine shop for aeroplane motor repair work. Estimated cost $350,000.

Wash., Longview—M. & M. Plywood Co.—machinery and equipment, for the manufacture of plywood, also boilers, engines, etc., for proposed 1 story, 80 x 1,750 ft. mill. Estimated cost $50,000.

Ont., St. Catherines—Thompson Products Co., C. E. Thompson, Pres., 2196 Clarkwood Rd., (auto accessories)—lathes, milling machines, etc., for proposed 1 story manufacturing plant. Estimated cost $150,000.

Ont., Sarnia — Electric Auto Lite Co., Champlain and Mulberry Sts., Toledo, O.—prices on equipment for proposed factory on North Sarnia St. here. Estimated cost $150,000.

Ont., Walkerville—Motor Products Corp., E. H. Cair, Mgr.—machinery and equipment for the manufacture of motors specialties for proposed 1 story, 150 x 200 ft. addition to factory on Walker Rd. Estimated cost $100,000.

Opportunities for Future Business

Calif., Berkeley—University of California, is having plans prepared for the construction of a group of college buildings, including electrical and mechanical departments. Estimated cost $600,000. G. W. Kelham, 315 Montgomery St., San Francisco, Archt. Noted Aug. 1.

Calif., El Monte — Fokker Aircraft Co. awarded contract for the construction of a factory on Valley Blvd. Estimated cost $350,000.

Calif., Los Angeles — Gunn Furniture Co., 1027 South Broadway, awarded contract for the construction of a 2 story factory. Estimated cost $40,000.

Calif., Los Angeles—Willard Storage Battery Co. awarded contract for the construction of a group of factory buildings including administration building on East 9th St. Estimated cost $350,000.

Calif., Sausalito—W. H. Von Der Werth, East Morrison St., Portland, Ore., plans the construction of a yacht harbor, clubhouse, etc., including shops, here. Estimated cost $250,000.

Conn., Stamford — Norma Hoffman Bearings Co., Hamilton St., is receiving bids for the construction of a 1 and 2 story, 100 x 200 ft. factory on Hamilton St. Estimated cost $125,000. Fletcher-Thompson Inc., 542 Fairfield Ave., Bridgeport, Archt.

Calif., South San Francisco—Enterprise Oil Burner Co., 2902 19th St., San Francisco, acquired a site and plans the construction of a plant at Bayshore Highway. Estimated cost to exceed $75,000.

Conn., Hartford—Superior Spring & Mfg. Co., 373 Washington St., is having plans prepared for the construction of a factory. Estimated cost $65,000. G. L. Dunkelberger, 721 Main St., Archt. Noted Sept. 13.

Conn., Waterbury—Super Service Inc., c/o Fletcher Thompson Inc., 542 Fairfield Ave., Bridgeport, Archt., awarded contract for the construction of a 2 story, 60 x 150 ft. garage on Willow St. Estimated cost $50,000. Noted Sept. 5.

Ill., Chicago—Hafner Mfg. Co., 3128 Carroll Ave., manufacturers of toys, awarded contract for a 1 story, 100 x 301 ft. factory at Kohner Ave. and Augusta St. Estimated cost $33,000.

Ill., Chicago—Wittek Mfg. Co., 2532 South Kedzie Ave., manufacturer of hose clamps, awarded contract for the construction of a 1 story, 52 x 104 ft. factory at 4305-11 24th Pl. Estimated cost $15,000.

Ill., Evanston—Stanley & Co., plans the construction of a 1 story, 44 x 100 ft. factory at 1102 Dodge Ave. M. & Q. Lock Co., lessee.

Ia., Sioux City—L. G. Everist, Inc., 2100 East 4th St., (sand, gravel and cement), plans the construction of an office, yards and machine shop at Dace and Virginia Sts. Estimated cost $100,000.

Ia., Sioux City—International Harvester Co., awarded contract for the construction of a 1 story, 150 x 225 ft. sales and service building at Dace and Virginia Sts. Estimated cost $150,000.

Ia., Sioux City — Kari-Keen Mfg. Co., c/o C. H. Meyers, 7th and Division Sts., awarded contract for the construction of a 1 story, 88 x 286 ft. auto luggage carrier factory. Estimated cost $50,000.

Kan., Atchison—Locomotive Finished Material Co., will build a 115 x 400 ft. foundry with 30 ton and 10 ton cranes, also material building 86 x 300 ft. to be equipped with 10 ton cranes.

Mass., Brighton (Boston P. O.) — Wood Hydraulic Hoist & Body Co., 316 North Beacon St., will build for additional unit to plant, 1 story, 50 x 180 ft. plant.

Mass., Quincy—J. Asnes, 63 Stewart St., will build a 1 story, 80 x 100 ft. repair shop and service station on Stewart St. Estimated cost $40,000. Private plans.

Mass., Salem—G. Garfield, 24 Milk St., Boston, had plans prepared for a 1 story ,50 x 200 ft. service and repair shop at 66 Bridge St. Estimated cost $45,000. Private plans.

Mass., Salem—M. Koski, 403 Bridge St., will build a 1 story repair and service garage on Pope St. Estimated cost $40,000. Private plans.

Mich., Lansing—State of Michigan, Administrative Board, awarded contract for the construction of a 3 story vocational school. Estimated cost $300,000.

Mass., Westfield—Martin Trailer Co., plans the construction of a 1 story, 80 x 100 ft. factory. Estimated cost $50,000. Private plans.

Mich., Detroit—Chrysler Corp., East Jefferson Ave., awarded contract for the construction of a 1 story, 160 x 160 ft. machine shop in connection motor car factory. Estimated cost $75,000.

Mich., Grand Rapids—Terrell Equipment Co., Hall and Century Sts., awarded contract for a 2 story, 98 x 348 ft. addition to factory for the manufacture of metal office furniture. Estimated cost $60,000.

Mich., Muskegon—Vento Steel Sash Co., 6th St. and Pennsylvania R.R., awarded contract for the construction of two 1 story factory buildings, 25,000 sq.ft. to be machine shops to produce steel sash. Noted Sept. 26.

Minn., St. Paul—Northwest Airways, Inc., L. H. Brittin, V. Pres. and Mgr., Merchants National Bank Bldg., awarded contract for the construction of a 130 x 200 ft. hangar, 30 x 100 ft. office and 30 x 200 ft. machine shop at Municipal Airport. Estimated cost $100,000.

N. H., Pittsfield—A. M. Pellissier, awarded contract for the construction of a 1 story, 70 x 135 ft. repair and service garage. Estimated cost $40,000.

N. J., Bound Brook — Radio Corp. of America, Woolworth Bldg., 233 Broadway, New York, N. Y., is having sketches made for the construction of a 2 story television and experimental building here. Private plans. Maturity after January.

N. J., Newark—M. A. Wolf, 845 Broad St., Archt., will receive new bids about Nov. 15 for a 3 story, 160 x 200 ft., garage on South St. for Vogt Bros. Inc., 19 Frelinghuysen Ave. Estimated cost $150,000. Noted Aug. 29.

N. J., North Bergen—General Box Top Co., c/o Bonanno Bros., 1827 Bergen Turnpike, Contr., will build a 2 story factory at 39th St. Estimated cost $68,000.

N. Y., Brooklyn—Court Sq. Sales & Renting Corp., J. Weinstein, Pres., 26 Court St., plans the construction of an 8 story, 100 x 159 ft. garage at Boerum Pl. and Pacific St. Estimated cost $375,000. J. S. Kenendy, 157 Remsen St., Archt.

N. Y., Brooklyn—Dept. of Parks, New York, plans the construction of a 45 x 153 ft. garage and shops at Prospect Park and 5th St. here. Estimated cost $40,000. J. S. Kennedy, 157 Remsen St., Archt.

N. Y., Brooklyn—Trojan Holding Co., S. Hemmelstein, 32 Court St., will build a 2 story, 100 x 100 ft. garage, etc. at New York Ave. and Hawthorne St. Estimated cost $60,000. G. I. Prowler, 367 Fulton St., Archt. Maturity December. Noted Sept. 19.

O., Cleveland — City, W. R. Hopkins, City Mgr., will receive bids until Oct. 11 for the construction of a 1 story, 80 x 180 ft. garage and repair shop at East 110th St. and Leurer Ave. Estimated cost $100,000. H. Kregelius, City Hall, Archt.

O., Cleveland—Truscon Steel Co., 6100 Hydraulic Ave., will build a 1 story, 70 x 290 ft. factory. Estimated cost $40,000.

O., Massillon—Central Alloy Corp., plans extensions and improvements to mill to include continuous pack and pair furnace and electric drive equipment, here, also a 100 x 108 ft. normalizing furnace at Canton. Estimated total cost $600,000.

O., Medina—A. I. Root Co., plans the construction of a 1 story, 90 x 200 ft. factory for the manufacture of bee keepers supplies. Estimated cost $40,000.

Ore., Portland — Pacific Telephone & Telegraph Co., 352 Oak St., plans the construction of a new office, shops, garage, storage building, etc., at East 44th and North 44th Aves. Estimated cost $375,000 to $400,000.

Pa., Erie—General Electric Co., River Rd., Schenectady, N. Y., awarded contract for the construction of a 1 story alloy foundry on East Lake Rd. here. Noted Sept. 19.

Pa., Philadelphia—United Motor Service Co., 342 North Broad St., awarded contract for the construction of a 1 story, 150 x 260 ft. sales and service station at Hunting Park and Germantown Aves. Estimated cost $200,000. Noted Oct. 3.

W. Va., Huntington—International Nickel Co., A. S. Shoffstall, Gen. Mgr., 67 Wall St., New York, N. Y., awarded contract for the construction of two new units to plant, also larger unit, 158 x 400 ft., to be cold drawn department of plant.

Pa., Tarentum — Tarentum Steel Corp., G. Robinson, Pres., 1716 First National Bank Bldg., Pittsburgh, is having plans prepared for the construction of a 1 story steel mill here. Estimated cost $3,000,000. L. F. Galbraith, Tarentum, Ch. Engr.

Utah, Park City — A. and R. Kimball, awarded contract for the construction of a garage. Estimated cost $52,000.

Wis., South Milwaukee—Line Material Co. is receiving bids for a 3 story, 60 x 120 ft. factory. Private plans.

Ont., Arnprior—Canadian Public Booth Co. Ltd., plans addition to plant. Estimated cost $50,000.

Ont., St. Catherines—W. S. Tyler Co., 3615 Superior Ave., plans the construction of a manufacturing plant here. Estimated cost $500,000. G. S. Rider Co., Century Bldg., Cleveland, O., Archts.